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MERICAN SOCIETY for METALS

Machinability of National Emergency Alloy Steels

By O. W. Boston
Professor of Metal Processing
College of Engineering
University of Michigan

ANY DISCUSSION of the machining characteristics of the newly developed low alloy steels known as the National Emergency steels, or more simply as NE steels, of necessity at this time must be based on meager data from a few available sources. Most of these steels are so new that heat treatments for optimum machinability and machining practice have not been standardized. Revisions in their analyses have been made at two dates in substituting substitutes for substitutes, as the shortages of alloying elements vary from time to time. Even those remaining National Emergency steels on the high side in critical alloys (at first substituted for the S.A.E. alloy steels) are destined for replacement by the leaner types in the present list. The latest NE steel specification list (approved December 17, 1942) was printed in METAL PROGRESS in January, 1943, page 90. Only those whose work can justify it will be permitted to use the richer types of steels such as the NE8442, 8600 series, 8720, 9500 series, 9600 series, and the 52100 series. The leaner, or low alloy, types consist essentially of the NE1300 series (carbon-manganese), NE8020 (manganese-molybdenum), the 9200 series (silicon-manganese and silicon-manganese-chromium steels), and the 9400 series (manganese-silicon-chromium-nickel-molybdenum). Because so much of our imported manganese has been cut off, it is doubtful whether NE1300 steels will be long available for general use.

It may be noted that the NE1300, NE9200, and NE52100 series are quite similar to the former A.I.S.I. and S.A.E. series of the same numbers.

Classification — The National Emergency Steels may be divided into three general classes:

1. Carburizing steels containing up to 0.28% carbon, which are used where a very hard wearing surface is to be accompanied by good toughness and shock resistance in the core of the finished part. These steels may be machined in the hot rolled, annealed, or cold finished condition. The structure is blocked lamellar pearlite and free ferrite. As expected, cold finishing improves their machinability.

2. So-called "semi-thorough hardening" grades containing from 0.28 to 0.40% carbon include water-hardening and oil-hardening types. They are generally used for parts requiring from 100,000 to 150,000 psi. tensile strength (corresponding to a Brinell hardness range from 200 to 300). Some are used in the normalized, or normalized and tempered condition, with tensile strengths of 65,000 to 105,000 psi. This class of steels is best machined in the normalized or annealed condition, but may be machined at a sacrifice in speed in the cold finished, or quenched and tempered condition.

3. "Thorough hardening" grades, containing more than 0.40% carbon, all of which are oil hardening, may be divided into the following four subdivisions: *(a)* Those used in the full-hardened state, tempered to about 400° F. with resultant Brinell hardnesses of 550 to 600 and tensile strengths of 275,000 to 300,000 psi. *(b)* Those treated to Brinell hardnesses of 350 to 450, with tensile strengths of about 175,000 to 225,000 psi. *(c)* Those treated to Brinell hardnesses of 260 to 350 with tensile strengths of about 125,000 to 170,000 psi. *(d)* The high-carbon 52000 series used for ball and roller bearings, which have unusually high resistance to wear, and used at the maximum hardness obtainable for the section involved. All these thorough hardening grades

are best machined in an annealed condition, preferably with a spheroidized structure. However, it frequently happens that better machinability results from a normalized structure than from the annealed structure, even though the hardnesses are identical.

Specific information relative to the machinability of National Emergency steels has been obtained from a number of manufacturers. It appears that they are not unanimous in giving them a favorable machinability rating. One manufacturer of tractor hoists and cranes states, "The steels are much harder to machine than the S.A.E. steels they replace. The manganese seems to accumulate in hard spots or veins in the steel, making the machining operation extremely hard on tools. For this reason cemented carbide tools are frequently damaged by shattering."

A manufacturer of transmissions states, "When turning gears and shafts annealed to a Brinell hardness of 137 to 187 with molybdenum high speed tools under an emulsion at 80 ft. per min. with depth of cut of 0.014 in., there has been no noticeable difference in machinability between the substitute steels now in use and the steels formerly used. It has not been necessary to alter physical properties, change the machining practice, or grind tools more often. It should be pointed out that our experience in actual production with the NE steels has been somewhat limited. Most of the work has been done with the NE8000 series and the machining characteristics seem to compare favorably with those of the S.A.E.4320, the A.I.S.I.6120, and the Amolas (S.A.E.4000 series)."

A large motor manufacturer now converted to war work gives his general conclusions as follows: "We are inclined to believe that the new steels will machine at least as well as the old ones, and this opinion seems to be shared quite thoroughly throughout the industry."

A large truck company now engaged on war work observed that "no machining trouble has been experienced with NE steels and they appear to machine as easily and with as good finishes as do the older higher alloy steels".

A large gear manufacturer advises that in replacing S.A.E.4620 steel with NE8620 steel (containing alloy on the high side) in turning operations based on speeds of 60 to 100 ft. per min. and feeds of approximately 0.010 in., no difficult problems were encountered. From a point of view of finish produced, many of the NE heats processed (material either annealed or normalized) have given less trouble in turning and better surface finish than the S.A.E.4620 steel formerly used.

Case Histories

Various case histories have been submitted by users of NE steels, as follows:

NE1300 — The NE1300 series steels of the carbon-manganese type comprise five specific analyses ranging from NE1330 to NE1350. A company engaged in supplying cold finished steel reports that all of these grades in the as-rolled cold-drawn condition have machinability ratings in per cent based on bessemer screw stock B1112 (whose cutting speed of 180 surface feet per minute, or sfm., is rated as 100%) with a favorable chip character designated as "broken and hard", as follows:

NE1330, 64%, or 115 sfm. with a chip character continuous and semi-hard.

NE1335, 60%, or 110 sfm. with a chip character continuous and hard.

NE1340, 58%, or 105 sfm. with a chip character continuous and hard.

NE1345, 58%, or 105 sfm. with a chip character continuous and hard.

NE1350, 53%, or 95 sfm. with a chip character continuous and tough.

The former A.I.S.I. A1320 steel, which was not included in the NE list, had a machining rating of 54% or 98 sfm., with a chip character continuous and hard.

NE52100 — The NE52100 series of steels should be spheroidized annealed for best machinability. These steels machine with difficulty and in general may be rated at approximately 30% of that of bessemer screw stock. NE52100A is very similar chemically to the old S.A.E.52100, and should be indistinguishable in a machine shop. NE52100B and C have considerably lower chromium. Information on how this will affect the machinability of properly spheroidized stock is not yet available to the writer.

NE8024 (manganese-molybdenum) has been substituted for S.A.E.3115 (nickel-chromium) steel by a well-known tractor company. The NE steel was machined in an annealed condition with hardness ranging from 143 to 170 Brinell. Little distinction between the machinability of the new material and that formerly used was noticed.

NE8620 is reported by a large gear machining company as replacing S.A.E.4620. It was found that the number of pieces per grind of the cutter on a three-spindle Gleason rougher averaged 420 pieces for both steels when producing an 11-tooth differential side pinion. The rougher had a cutter speed of 147 ft. per min. and a feed of 16 sec. per tooth. The point width of cutter at the bottom of the cut was 0.110 in. and at the top of cut 0.516 in.; depth of cut was 0.375 and the length of the tooth

face was 1 in. A sulphurized mineral oil was used as a cutting fluid and the steels were annealed for the machining operation to give a hardness of 143 to 163 Brinell and a blocky type structure of pearlite and ferrite. When the above part was finished on an 8-in. manufacturing speed Gleason machine having 420 cutter strokes per min. and a feed of 5 sec. per tooth, removing 0.030 in. stock from each side to a tooth depth of 0.370 in., the number of pieces per grind was 100 to 110 for both steels. Again the sulphurized mineral oil was used as a cutting fluid. Finish, as determined by meshing the teeth with a master on a spring fixture to observe eccentricity readings, and judging the variations in bearing position, showed no particular difference between the two steels.

A Precision Lathe Is Used for Determining Machinability Ratings of Various Carbon and Alloy Steels at Middletown Research Laboratories, American Rolling Mill Co.

When rough cutting a 16-tooth differential side gear on a Gould and Eberhardt bevel gear rougher, using a cutting speed of 271 ft. per min. and a feed of 4.6 in. per min., practically no difference in machinability was found between the S.A.E.4620 and the substituted NE8620 steel. The steel in both cases was machined in an annealed condition in which a Brinell hardness range of 143 to 163 was obtained with a blocky type structure of pearlite and ferrite.

Finishing this gear was done on an 8-in. manufacturing type Gleason generator, using 420 cutter strokes per minute and a feed of 4.7 sec. per tooth. From 0.026 to 0.030 in. of stock was removed from each side of the tooth to a depth of 0.370 in. Approximately 60 to 70 pieces were obtained per grind of the cutters. Practically no difference in machining results was noted between that of the high alloy S.A.E.4620 steel and the new NE8620 steel.

The same company reported that in roughing a 39-tooth spiral bevel ring gear on a 15-in. Gleason generating machine with a feed of 19 sec. per tooth and a cutter speed of 119.32 sfm., from 25 to 30 pieces per grind of the cutters were obtained on the S.A.E.4620 steel and from 20 to 25% more parts were obtained from the NE8620 steels annealed to the same hardness (143 to 163 Brinell) and having a blocky type structure of pearlite and ferrite.

The above gear was finished on a 15-in. Gleason spiral bevel gear generator using a feed of 42 sec. per tooth and a cutter speed of 139 sfm. About 0.030 in. of stock was removed from each side of the teeth to a total depth of 0.552 in. Approximately 20 to 25 pieces were produced per grind of the cutter. In several cases an improvement in finish and uniformity of bearing position was shown on the NE steel.

Another case reported by a large motor manufacturer engaged in war work involved the substitution of NE8620 steel for an S.A.E.4620 steel formerly used. The material in both instances was cycle annealed to give a Brinell hardness of 179 to 207. The part machined was 4 in. in diameter. Molybdenum high speed steel tools of the Mo-Tung type were used which were $\frac{1}{2}$ in. wide by 1 in. height of a form of 12° back rake, 6° side rake, 6° end and side relief, 13° end cutting edge angle, 0° side cutting edge angle, and $\frac{1}{8}$ in. nose radius. An emulsion of one part of soluble oil mixed with 34 parts of water flowed fully on work and tools. Cutting speed in rough turning was 90 sfm. and for finish turning 120. The feed for both steels was 0.012 in. per revolution, and the depth was $\frac{3}{32}$ in. for a $\frac{7}{8}$-in. facing cut. In this substitution no change in machinability characteristics was noted.

A tractor company also reported that NE8620 steel served as an excellent alternate for S.A.E.4615 and 4620 steel, and that the machinability was equally good.

NE8720, reports a well-known gear manufacturer, was substituted for S.A.E.4820 in a spiral bevel differential drive pinion. 80 pieces per cut-

ter grind were obtained in both instances. Both materials were annealed to give a blocky type of structure of pearlite and ferrite and a Brinell hardness ranging from 143 to 163. The work was done on a 15-in. Gleason generator with a feed of 29 sec. per tooth and a cutter speed of 157 ft. per min. The point width of the cutter at the bottom of cut was 0.060 in. and at the top 0.525. The total depth of cut was 0.560 in. and the tooth face length was 1.625 in.

Again, in finishing this gear on a 15-in. spiral bevel gear generator, using a feed of 44 sec. per tooth and a cutter speed of 139 ft. per min., the machinability was found to be approximately the same for NE8720 and S.A.E.4820. About 0.030 in. of stock was removed from each side of the tooth to a total depth of 0.552 in. From 135 to 140 pieces were produced per cutter grind.

The large automotive company engaged in war work substituted NE8720 steel for S.A.E.4815 steel. The part, $3\frac{3}{4}$ in. in diameter, was cycle annealed to give a Brinell hardness of 179 to 207. Tool shape and coolant were the same as specified four paragraphs above. Rough turning was done at 90 sfm. on both steels and finish turning was done at 120 sfm. with a feed of 0.012 in. per revolution in each case. A facing cut had a depth of $\frac{3}{32}$ in. for a radial distance of $\frac{15}{16}$ in. There was a considerable improvement in machinability of the NE8720 steel over that of the S.A.E.4815 steel, inasmuch as 65 parts were produced per grind with the S.A.E. steel while 85 parts were obtained with the NE steel.

A gear and axle manufacturer reported that an NE8720 steel replaced S.A.E.4620 steel for a large gear blank 12 in. in diameter and $1\frac{1}{2}$ in. thick. The material was normalized to give a Brinell hardness of 163. Molybdenum-tungsten (6-6) high speed steel tools were used after being hand ground. A stream of soluble oil was poured on the tool. Turning was done at 178 sfm. with a depth of cut of 0.125 in. and a feed of 0.010 in. Sixty pieces were obtained per tool grind. This value conforms favorably with that obtained on the S.A.E.4620 steel which was replaced. It was concluded that in turning and milling the steel in a normalized condition, NE8720 compares favorably with S.A.E.4620.

NE8724 — A tractor company employed NE8724 as an alternate for S.A.E.4820 (high Ni-Mo). In the new steel molybdenum was preferably near the maximum of 0.30% to give the same penetration of hardness and good core properties of heavy-sectioned gear teeth. The annealed hardness of NE8724 was from 143 to 173 Brinell, but if lower than 156 the machinability became poor, that is, poor surface finish resulted on the gear teeth produced on Gleason and Fellows shapers. In the range of 163 to 187 Brinell, machinability of the new steel was found to be superior to S.A.E.4820.

NE8949 — The gear and axle company reported that the machinability of NE8744 and NE8944 steels, when normalized, compares favorably with S.A.E.3240 and 4340 in turning and milling operations. Further that NE8744, when oil quenched from 1550° F. and tempered at 700°, gives approximately 60% of the tool life of S.A.E.3240 and 4340 at the corresponding hardness (370 to 430 Brinell).

A milling machine manufacturer recently milled S.A.E.4345 and NE8949 steels with a spiral mill under identical conditions of cut. The two alloy steels have approximately equal depth hardening, yet they are widely different as to chemical composition.

On the sole basis of hardenability rating the two steels should have exhibited approximately equal cutting performance, but this was not the case, since NE8949 required more power and gave a poorer surface finish than S.A.E.4345, which exhibited excellent cutting characteristics.

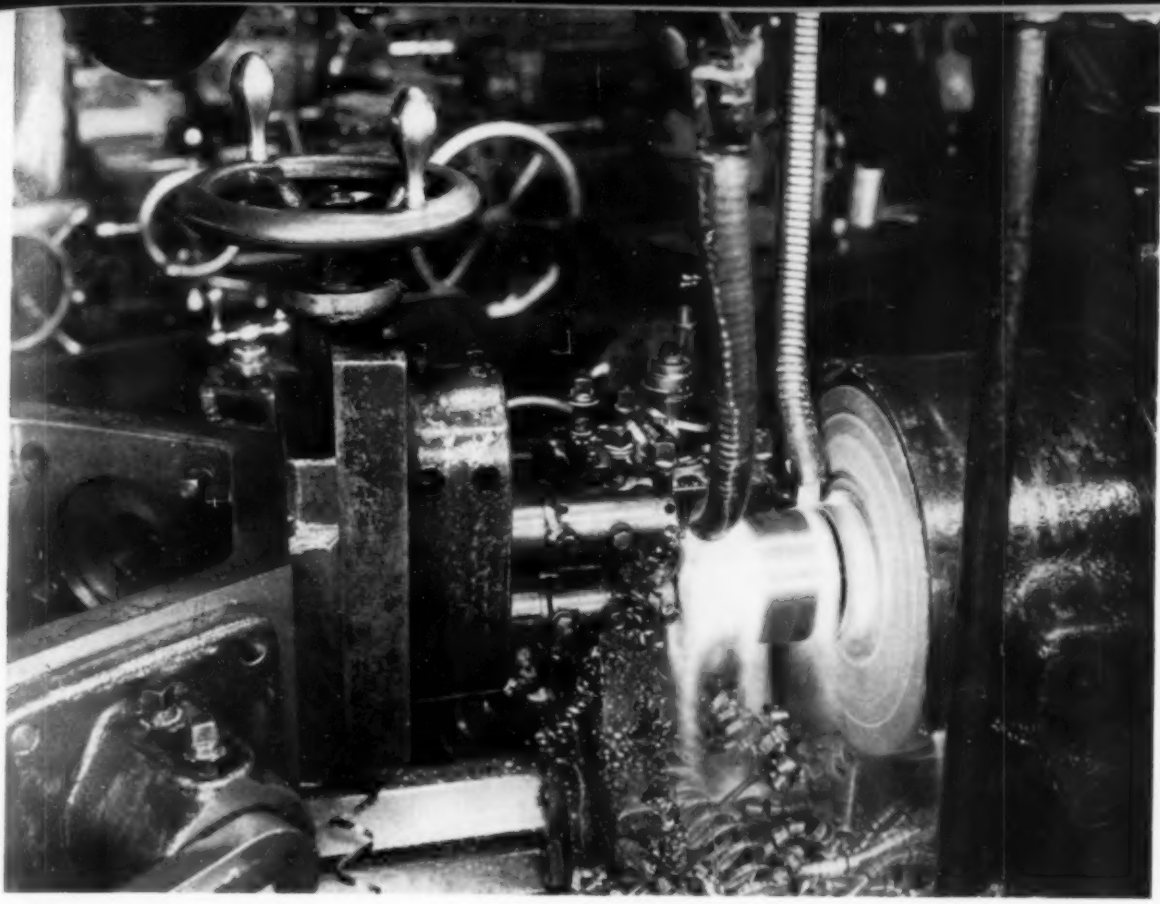
NE9200 — The NE9200 series of steels should best be annealed for machining. Their general rating, based on bessemer screw stock, is approximately 45% when annealed to a hardness from 187 to 255.

NE9400 — The 9400 series (manganese-silicon-chromium-nickel-molybdenum) are as yet too new and reports to date are not sufficient to permit anything but an estimate as to their machinability. The following approximations were submitted by a company engaged in the cold finishing of steel:

Approximate Machinability of NE9400 Steels

Designation	Machine Rating*	Turning Speed	Character of Chip
	As Rolled; Cold Drawn		
NE9415	55%	100 sfm.	Continuous and hard
NE9420	55	100	Continuous and hard
NE9422	53	95	Continuous and springy
	Annealed; Cold Drawn		
NE9430	64%	115 sfm.	Continuous and semi-hard
NE9435	60	110	Continuous and semi-hard
NE9437	60	110	Continuous and semi-hard
NE9440	58	105	Continuous and hard
NE9442	53	95	Continuous and tough
NE9445	47	85	Continuous and tough
NE9450	45	80	Continuous and tough

*100% = bessemer screw stock B1112, with cutting speed of 180 sfm.



Cutting Metal Fast at Timken Roller Bearing Co.

Tool Shapes and Lubricants

As most of the NE steels are machinable in an annealed or normalized condition, which permits relatively free cutting, cutting tools of high speed steel are adequate. Regardless of the composition of the toolsteel, a shape of turning tool appropriate for this work would be as follows: 8° back rake, 14° side rake, 6° end relief, 6° side relief, 6° end cutting edge angle, and 15° side cutting edge angle. The nose radius should be large, but not in excess of 10 or 20% of the depth of cut to be used. If cemented carbide tools are used, a back rake angle of from 0 to —5° may be used, a side rake angle of from 5 to 10°, side and end relief of 5°, an end cutting edge angle of 6°, a side cutting edge angle of from 0 to 15°, and a nose radius of $\frac{1}{32}$ in.

In general, standard drills and milling cutters can be used with rake angles from 10 to 15° on the milling cutters. In threading, a rake of from 10 to 15° will give good results with chip space or flute ground smooth to a full radius.

In general, emulsions of soluble oils are satisfactory for turning, milling, and drilling, when these operations employ relatively high cutting speeds. For low cutting speeds — as used in broaching, reaming, and threading — sulphurized mineral oils should be used. A mixture of mineral oil plus from 10 to 15% fatty oil serves as a good substitute for the sulphurized mineral oil.

Cutting fluids should be at low temperature, and applied in large quantity and at high velocity in order to be most effective.

In conclusion, it may be stated that the machinability of the current National Emergency steels corresponds favorably with the former A.I.S.I. or S.A.E. steels replaced. It must be remembered that "machinability" is a broad term, and may refer to any one of several phases of the metal cutting operation, such as long tool life, well-broken up chips, good surface quality, and low power consumption. Further, the machinability may be a function of the metal cutting process, so that for broaching, for example, the rating of a steel must be based on surface quality, dimensional accuracy, and chip formation rather than on tool life. In many operations such as gear cutting, form turning, or threading, *finish* in itself is more important than tool life. Chip formation in many instances, such as in automatic screw machines and turning machines, may be of primary importance because of the difficulty of disposing of long continuous chips; if these are not cleared promptly they may mar the machined surface or may tangle with tools and spindles.

Tool angles, cutting speeds, and ratio between depth of cut and feed will have to be adjusted in order to produce the most favorable results required for each job. When this is done, satisfactory results will follow. One progressive firm has long taken the attitude that anything can be machined! A difficult subject is then but a spur to an intelligent attack and improved technique.

By Joseph Geschelin

Chairman
Independent Research Committee on Cutting Fluids; Detroit, Mich.

Have You Recently Appraised the Cutting Fluids?

IMPACT of the global war on metal working establishments has made it necessary for management to concentrate on many pressing problems of immediate importance. Yet when it is realized that good machine shop practice is an integration of many elements — some of which may appear to be of minor importance — it is easy to see how many details must be under control. Certainly, now that most programs are well under way it is well to take stock and to explore every avenue that may be fruitful of further economies in production.

One of the elements of metal cutting that should be emphasized at this point is that of cutting fluids. Although they represent a relatively small percentage of the cost of expendable materials, they are responsible to a large degree for the success or failure of many metal cutting operations.

Accordingly, it is strongly recommended that steps be taken to appraise the cutting fluids. Needless to say, metal cutting encompasses a number of factors that must be taken into consideration, such as — to mention but a few —

1. The type of metal to be cut.
2. The type of tool material to be used.
3. The character of dimensional tolerances.
4. The nature of surface finish.
5. Proper selection of speeds, feeds, depth of cut.
6. Tool design.

Generally speaking, careful attention is given to such details. Yet it is a fact, borne out by actual experience, that a change in cutting fluid on an established set-up may increase production from two to ten times, and may make the difference between a fine finish and a poor one.

Even if cutting fluids have been given due consideration in the past it is well worth a careful re-check under present conditions. The need for this is apparent when you consider that materials specifications are in a constant state of flux. S.A.E. grades and designations have given way to A.I.S.I. grades, and these, in turn, have been replaced by the NE steels which will rapidly usurp the picture. Every time a change in materials is made there is a corresponding change in machinability — for better or worse — and each steel must be accompanied by a suitable adjustment in practice.

At one time the situation was greatly complicated by the variety of cutting fluids and proprietary materials, and by the lack of available literature and standards. In recent years, and particularly during this war, there has been a vast improvement along this line, what with the simplification of grades and variations. Today there exists a mass of literature, including the valuable work of the ⊛ Handbook Committee, which has provided much of the available information on cutting fluids in the National Metals Handbook. In addition, the Independent Research Committee on Cutting Fluids has explored the field and is circulating its latest findings in generalized form.

Today the major producers of cutting fluids have a finely organized body of field engineers who are ready, upon request, to study operations in any plant and then to make suitable recommendations. Through the cooperation of these specialists it is a relatively simple matter to analyze cutting problems, to evaluate the variables involved, and to recommend the grades of commercial fluids that can best be applied.

Emulsifiable oils of various types provide the nearest approach to universal application, since

they are easy to handle and mix, are applicable to a wide variety of operations, and are relatively inexpensive. However, there is no such thing as a universal cutting fluid any more than there can be a universal cutting tool, or a single range of cutting speeds and feeds. Actually every production operation demands individual study.

At the present time the types of cutting fluids commercially available may be cataloged thus:

Kerosene
Lard oil
Mineral oils
Mineral-lard oils
Sulphurized oils
Oils containing both sulphur and chlorine
Soluble or emulsifiable oils

Each has its unique sphere of usefulness. Certainly it is dangerous to expect any one type or even two types to handle a range of operations such as drilling, thread grinding, surface broaching, cylindrical grinding, gear cutting, and sawing.

As a pointed example of the change in procedures, one may well consider the revolution in grinding practice brought about by the requirements of aircraft engines for fine surface finish on parts which are subject to magnaflux inspection. During the past two years the tendency has been toward the use of certain mineral oils which have had a marked effect upon the perfection of surface finish and the maintenance of fine dimensional tolerances.

Frequently as a matter of operating economy in a large machine shop, it is well to standardize upon a relatively few cutting fluids, supplied from a central storage station where the oils are properly mixed and piped to the machines, and to which all used fluids are recirculated for centrifuging and reclaiming. Even in such plants it is advisable to isolate specific operations which may demand special cutting fluids for best results.

Only by an actual analysis of the over-all problem is it possible to appraise the metal cutting situation and to make sure that best results are being obtained. In making such a survey, it is the recommendation of the Independent Research Committee on Cutting Fluids that the problem be resolved along the following lines:

1. A grouping of metals into major subgroups depending upon the percentage of ferrous or non-ferrous compositions.

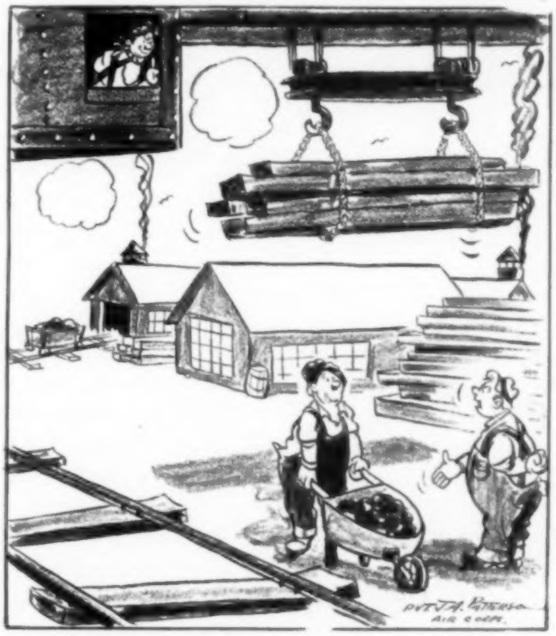
2. Evaluation of each of these in accordance with the machinability of each type.

3. Analysis of metal cutting according to the nature of the machining operation.

4. Further division according to the character of the cut — i.e., whether cuts are light, medium, or heavy.

Nothing to Do With Cutting Fluids

Courtesy J. A. Patterson and *The Foundry*



"Take a fool's advice, Hopgood — either shave off that moustache and comb yer hair right, or quit walkin' under them cranes!"

Immediately upon making this preliminary analysis, the engineer, expert in the problems of cutting fluids, can determine the general types of materials that should be applied. Usually it takes but a short shop test to determine the correct type or mixture to meet the individual problem.

In the light of the variables involved, this is a matter for the expert. And when it is appreciated that so simple an expedient as a change in cutting fluids can make a marked difference in the character of the surface finish, in tool life, in tool cost, and in actual production costs, it is obvious that no one can afford to delay the process. Remember, too, that proper analysis of the problem and selection of the right oil may double or triple productivity.

A valuable by-product of an investigation of this kind is that it is quite likely the machine shop will find further economies in improved tool practice — better tool forms, better tool materials for a specific operation, changes in speeds, feeds, and depth of cut.

Finally, it may be noted that good practice in the handling of cutting fluids is but one aspect of good machine shop practice. It should be incorporated as a definite responsibility of the standards department. If the plant is of such size as to have a chemist or metallurgist, cutting fluids might be made their responsibility, since these specialists are best qualified to evaluate the fluids and establish workable specifications which can be of greatest benefit to the plant and to the purchasing department.

By George F. Wolfe
Chief Plant Engineer
Engineering Works Division
Dravo Corp., Pittsburgh

Ships Welded on a Production Line

DRAVO Corp.'s Neville Island plant, at Pittsburgh, had long been building steel ships for the inland waterways, the hulls being constructed almost entirely by riveting. The plant was well organized, and fabricated about 2500 tons of steel a month, at most. For ten years, however, consideration had been given to the welding method as an original and unique method of manufacturing, and the ideas so conceived were applied in our reorganization of plants to handle large Navy contracts in three yards, the one in Pittsburgh, one on the East Coast, and one on the West. The course of events in Pittsburgh will be described in what follows, a brief rendition of a paper entitled "Production Line Welding Plant Speeds the Defense Program" submitted to the recent $200,000 prize program of the James F. Lincoln Arc Welding Foundation.

The ways at the Neville Island plant are of the side launching type. The total river frontage was definitely restricted by property lines and existing structures. The usual barge type of river craft is of a fairly simple structure and can be assembled in a few weeks, but the Navy vessels, being of a much more shapely and complex structure, usually require several months in the erection berth before they are ready to launch. Nevertheless it was necessary to continue the production of barges for oil, coal and steel, and to double the production of the yard — which in fact was done.

Reference to the sketch shown in Fig. 1 will show the location of the assembly line that was built in the summer of 1941 at Neville Island as a solution to this first problem of much additional way space without lengthening the river frontage and the sacrifice of too much of the productive area. The existing shop, arranged for the preparation of small sub-assemblies and individual plates for riveting together into hulls slowly growing on the ways, was entirely rearranged to produce large shop assemblies by the welding method. Transfer tracks were built to move the nearly completed hulls for river craft between this assembly plant and the sloping launching ways. This arrangement gives ample room for four naval vessels, side by side, while the transfer track system provides for the movement of the vessels progressively from position No. 1 to position No. 4, from which they are launched into the Ohio river, sidewise.

Transfer of hulls from place to place was done on the correct number of four-wheeled carriages, each of 120-ton capacity, carrying equalized hydraulic jacks on each corner, and running on very substantial steel tracks.

The space provided by this new layout was not sufficient in itself to meet the delivery schedule. Before any erection on a naval vessel was started in position No. 1, the entire hull — with the exception of that section comprising the engine room — was erected in an upside down position in the location shown in Fig. 1. Structural steel jigs, resting on concrete foundations, were provided for this preliminary assembly. These jigs were of a fairly simple nature, due to the inverted position of the ship, as it was only necessary for them to conform to the almost flat deck surface, and outline its edges.

This pre-assembly area was in turn provided with sub-assemblies built elsewhere. Platen jigs located near the upside-down assembly site served for the assembly of all frames before their entry into the larger units. In addition to this, all bulkheads were assembled on flat steel floors in the main structural shop (barge assembly shop) before being brought to the erection site.

The bulkheads entering into these vessels were of light gage plate with Tee stiffeners at frequent intervals. The result of the combina-

tion of considerable welding with light steel was unusual distortion, which had to be kept out or removed later with great expense and delay. After many experiments the method adopted was to first weld the joints of the individual plates and then tack the entire plate assembly securely to a flat steel floor before the addition of the stiffeners. A ½-in. bow was put in the stiffeners so that when they were forced down to the plate and tacked, the contact edges were in compression, thus offsetting the normal bowing from the subsequent welding. Welding of the stiffeners was then completed and the few resultant buckles were removed by the spot-heat-and-water-quench method.

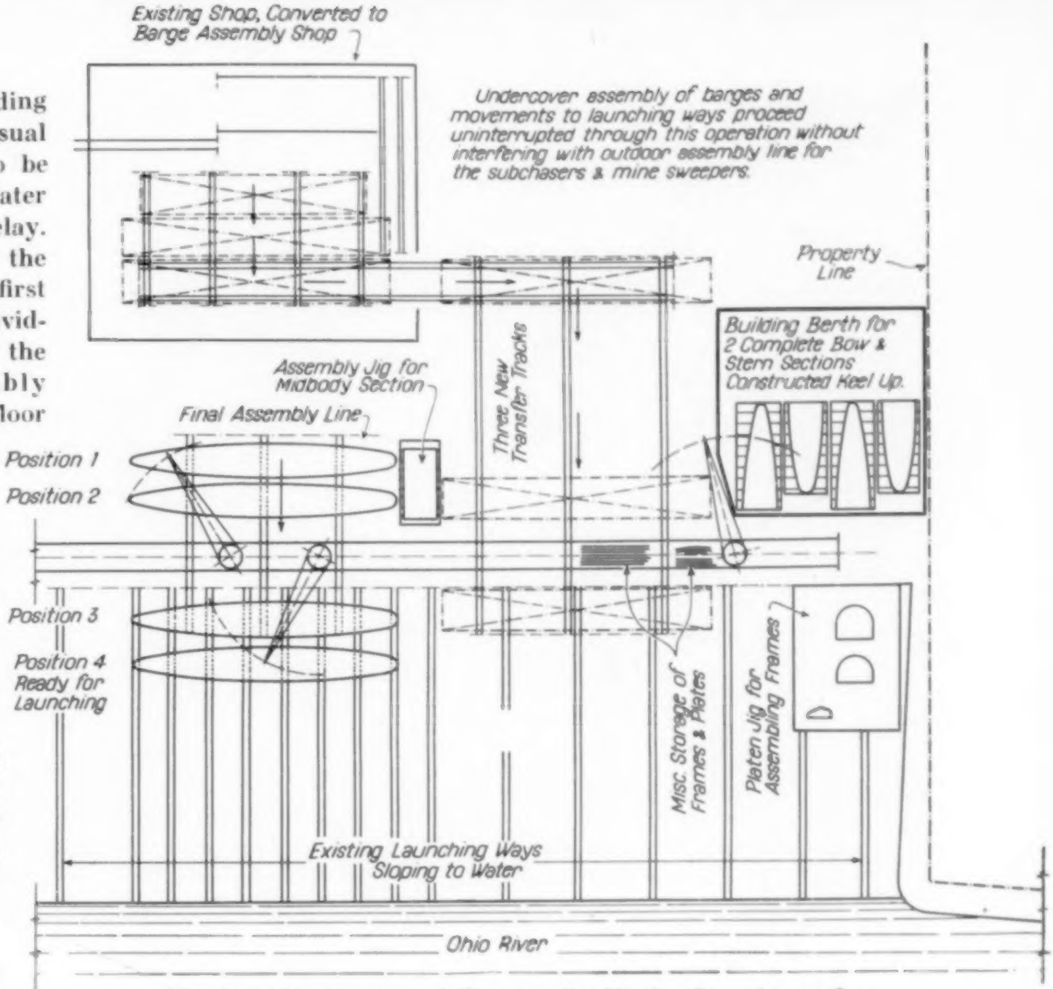


Fig. 1 — Arrangement of Plant to Double the Capacity and to Build Sub Chasers and Mine Sweepers in Addition to River Craft

Since the main hull sections were built in jigs in an upside down position, their transportation to the erection site in position No. 1 on the assembly line and the turning over of these sections had to be given careful study. The transportation problem was easily solved as several gantry cranes were available. Turning over these large, irregular pieces became the major problem. As the general cross-section of the hull, and particularly that of the bow section, approached a triangle, the center of gravity lay quite outside the center of rotation. Model tests were made to determine the critical positions to be encountered, and it was decided that turning should be done with block and tackle in order that hauling and snubbing would be coordinated. The photograph, Fig. 3, on page 553, shows this turning rig.

Forward and aft sections of the hull are set in place on permanent steel blocking carried on concrete foundations. The engine room section is already in place so the end sections, while still held by the main hooks of the two gantry cranes, are pulled home by turnbuckles attached to appropriate lugs. At each horizontal joint about 18 in. is left unwelded to facilitate fitting and to assist in controlling the over-all length of the vessel at this time.

Following the assembly of the first hull in position No. 1 and the finishing of enough welding to move it without fear of distortion, transfer carriages are placed in position and the entire assembly jacked up and moved to position No. 2. As additional hulls are erected the movement is progressively sidewise, toward the launching ways, and when the line is entirely filled the first hull is ready for launching, with all exterior under-water work completed and all of the heavy machinery in place.

Many benefits were shown in the assembly line methods, among which are the following:

1. A substantial reduction in fitting and welding time.

2. An over-all improvement in the quality of the welds in direct ratio to the amount of position welding obtainable.

3. Sectional construction allows relief points for locked-up shrinkage or internal stresses, so the vessel's over-all length will be correct.

4. A greater number of welders can be used with only average qualifications, i.e., qualified for down-hand welding only.

5. Conservation of launching way space.

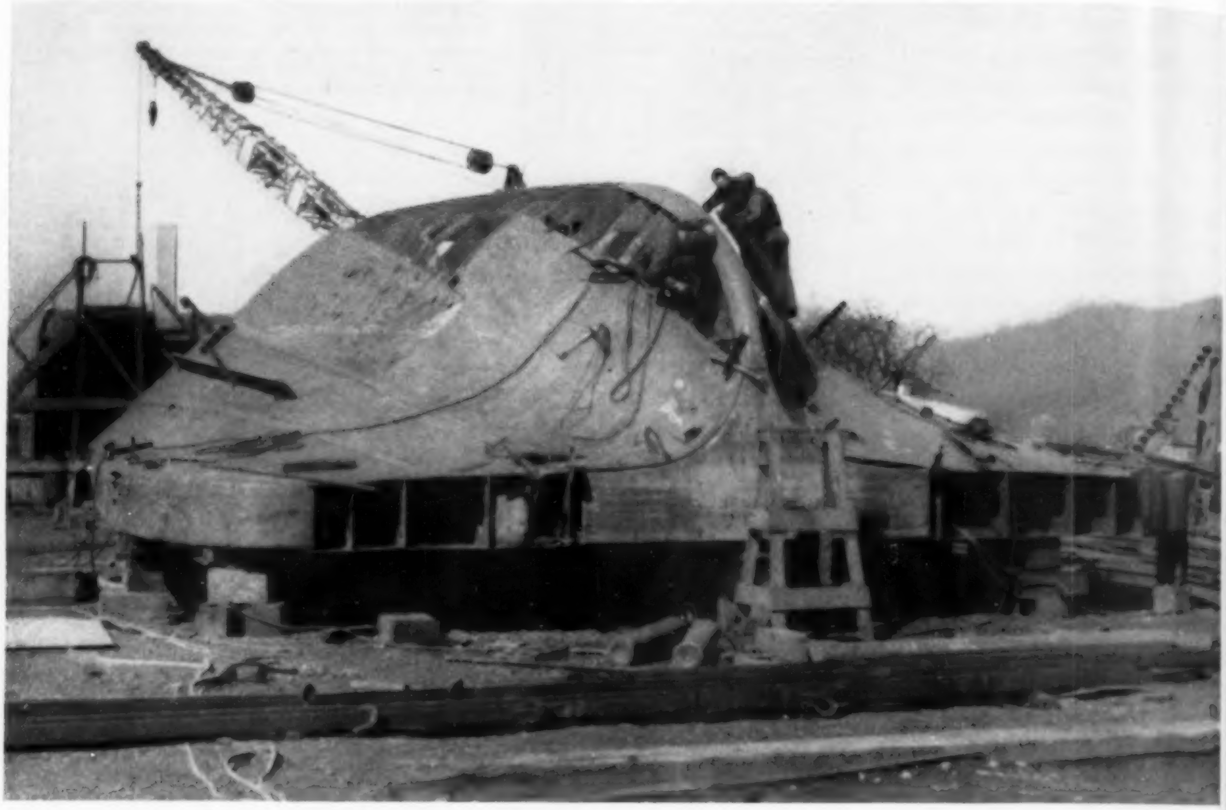


Fig. 2 — Combination of Upside-Down Assembly, Simple Jigs, and Adequate Crane Service, Insures Speedy, Economical and Sound Workmanship

Assembly lines for ships set up shop requirements not previously demanded. In order to keep the lines in motion it is necessary to deliver pre-assemblies to them as large as can be handled. The final results are greatly dependent upon the accuracy of such pre-assembled sections; therefore true and accurate sub-assemblies must be provided for.

Joining Stiffeners to Plates

One of the primary shop jobs is joining stiffening members to plating. As a hand operation, this is slow and expensive, requiring careful layout work on the plating and the tedious fitting of the stiffening members, which usually consists of an angle with toes contacting the plate. This problem required the design and development of the "fit and tack" machine shown in Fig. 4. This machine consists of a flat steel floor traversed by a fitting head. A plate is laid on the steel floor in a position determined by jigs, and the longitudinal stiffening members are dropped into jigged slots for approximate location. The fitting head is equipped with horizontal adjusting and vertical clamping motions, and is run over the assembly and holds the longitudinals firmly and accurately to the plate for hand tacking. When the job is done the head is run off in the clear at either end of the floor so that overhead cranes can unload the floor and reload the machine.

Adequate Assembly Jigs

Jigging of assemblies is utilized wherever possible. A recent visitor referred to the "fit and tack" machine as the most expensive jig he had ever seen, but the results have justified the investment. Numerous other jigs are used from the simple lugs on a flat plate for such items as rake or transverse frames up to an elaborate box-type of jig for a side section of a coal barge, 35 by 11 by 3 ft. in dimension. This assembly is one of four forming the entire side of a 175-ft. coal barge, and is largely dependent on proper and rugged jigging to insure that accuracy of shape and dimension necessary for the successful usage of large pre-assemblies.

Even larger jigs are required at times and for this purpose large plane steel floors are provided as a base for such jigs. A series of supports are tack welded to such a floor to jig the deck plates (the hull being erected upside down) and side lugs attached to these supports to fit the irregular gunwale. Similar jigs have been used in outdoor assembly, such as mentioned in the

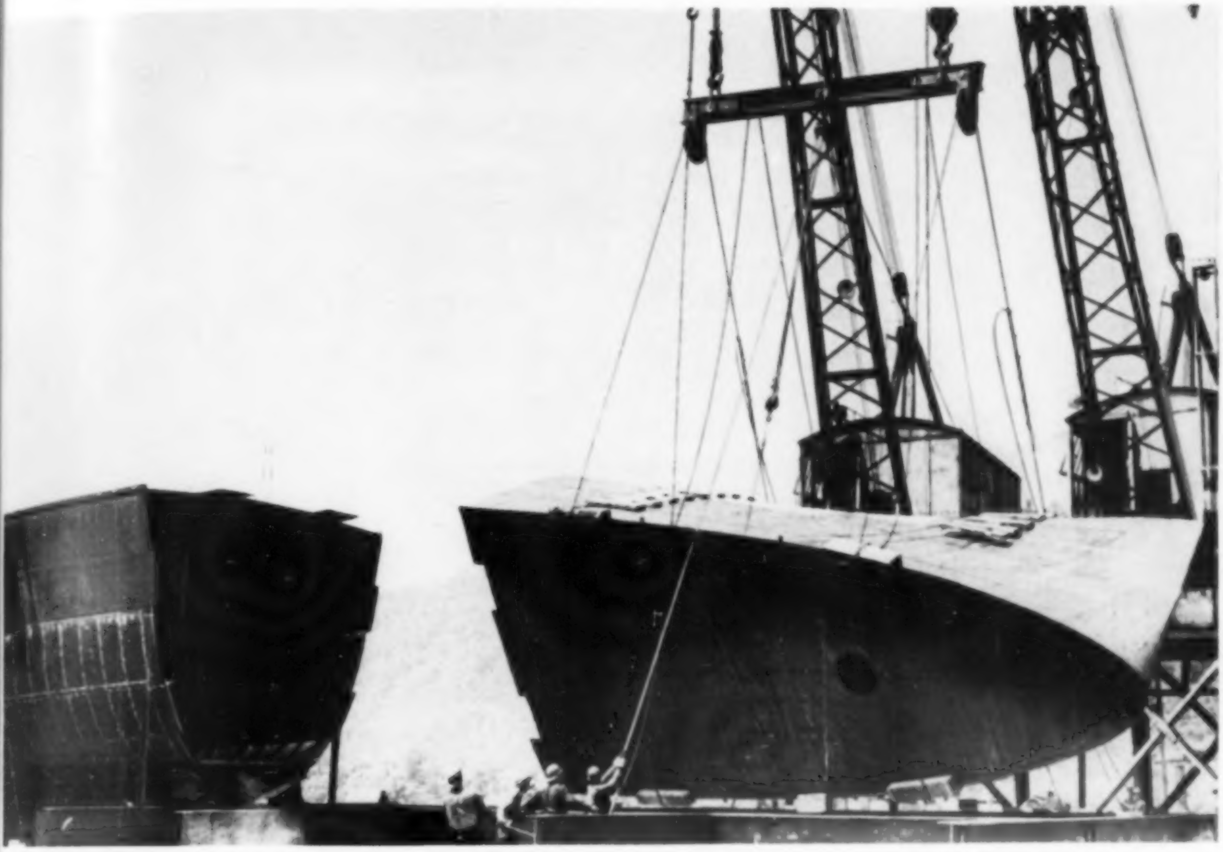


Fig. 3 — Bow and Stern Sections Were Completely Erected Upside Down, Moved Over to the Main Assembly on Transfer Cars, and Each Turned Over and Moved Up to the Engine Midbody Section by Two Whirler Cranes Acting in Unison

pre-assembly of sub-chaser hulls; Fig. 2 shows the erection of the entire forward section of a towboat having a beam of 36 ft. Similar jigs were used for the very irregular aft hull sections of this twin-screw, tunnel type towboat and it is needless to point out the economy of such a procedure — particularly where half a dozen vessels are built.

Every effort is made to get positioned welding, a matter whose value cannot be over-estimated. Tilting tables are used to their maximum capacities. Larger assemblies are juggled by overhead cranes and leaned against husky supports. Hand welding is the rule, and our training school is constantly preparing new men to qualify according to standards set up by the governmental inspection services and the American Bureau of Shipping.

Automatic or machine welding is not so adaptable to the large assemblies, which cannot readily be taken to a welding machine. Means must usually be devised for taking the machine to the assembly, and to design the joints so that long, continuous welds are made in accessible locations and in such number that the machine works practically continuously. The welding of side box sections for car floats is one successful application — approximately 10 miles of joints were so made on one lot of 14 vessels.

It is most difficult to show the value of a fabricating shop designed for welding as compared to other shops designed for riveted work, but during the past year the author had an unusual opportunity to definitely establish such a comparison. At governmental request a serious effort was made to subcontract a portion of the fabrication in order to accept additional work for which the Neville Island plant was particularly well equipped.

The fabricated steel to be sublet consisted of barge hulls of fairly simple design and of all-welded construction. Many shops were contacted within a 300-mile radius. Some of the bigger shops were unable to quote due to prior commitments so that the bids were representative of what we may call the average shop. The results, expressed in terms of excess price per ton over the selling price as already in the contracts, were:

Bidder A	$28.00 per ton excess
Bidder B	31.90
Bidder C	40.30
Average	$33.40 per ton excess

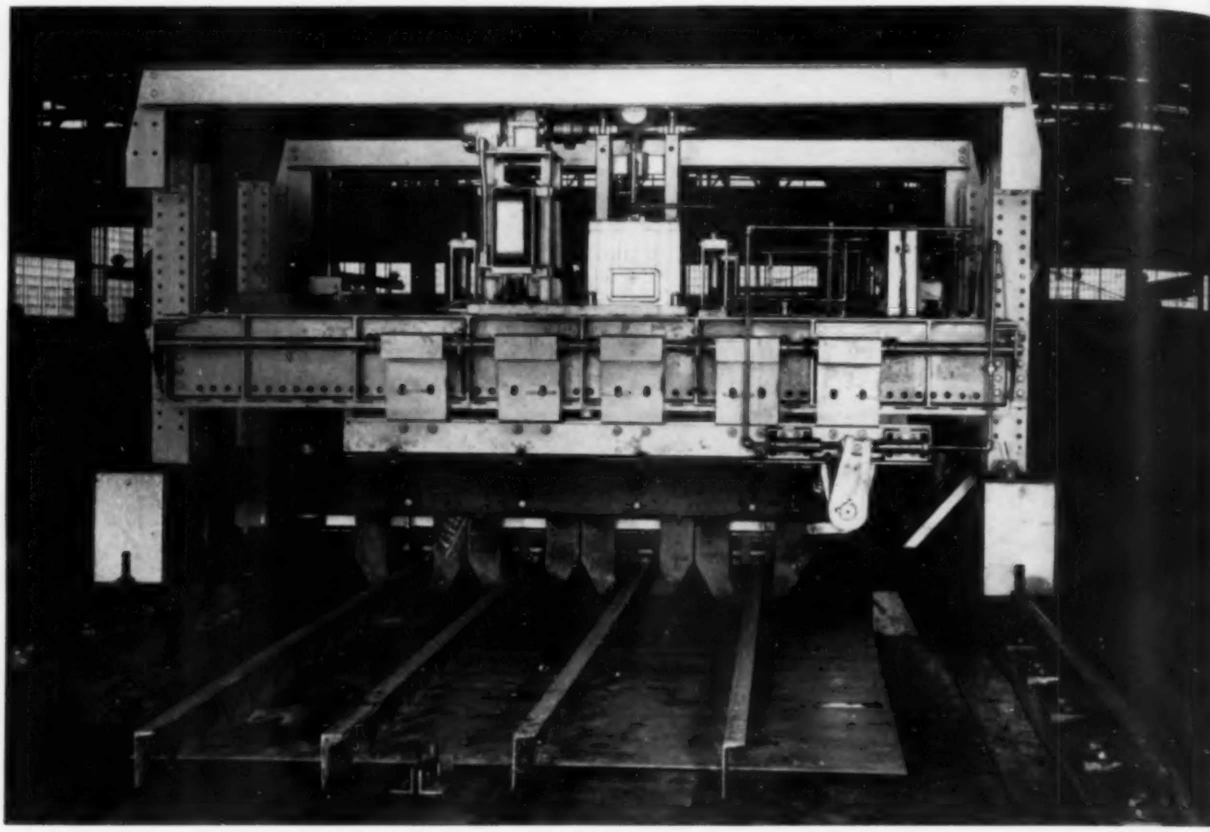


Fig. 4 — Fitting Head for Bulkheads — a Gantry With Adjustable Clamps or Fingers for Holding Stiffeners Down to the Plate for Hand Tacking. Stiffeners are structural channels split in web by die-equipped punch press

These bids were from the only alternate shops available in the latter part of 1941, and serve as a direct measure of the economy of a properly equipped fabricating shop. During the year 1941 the plant described herein fabricated a total of 47,000 tons of steel which, at a saving of $33.40 per ton, would show a total saving to the buyer of $1,569,800.

The application of production assembly lines to ship construction is out of the experimental stage and enough work has passed over such lines in the past two years so that the saving in cost has been definitely established. A conservative over-all saving can be placed at 10% of the entire cost of the work. Many factors contribute to this saving but the greatest factor is that of repetitive work by the men at each station. After the first few vessels are built on the line there is a marked step-up in production, since the workmen proceed without constant reference to drawings. Fitters soon recognize each piece by its marking or appearance; tackers know just what points require support; welders soon develop a special technique for each individual weld. A proper source of supply for the pre-assemblies permits these lines to guarantee steady work without those seemingly inevitable lay-offs, now and then.

This sudden and extensive adoption of the use of assembly line methods will undoubtedly affect all future shipbuilding. All of the yards now being built are being financed with government money and here again there is a large saving due to the economy of such installations. Savings of this nature all react to the general public welfare and will tend to speed the adoption of such methods by numerous shipbuilders in the future.

The savings in a modern fabricating shop have been very definitely established, but entirely new shops are under construction where experience already gained permits an even better choice and arrangement of equipment, resulting in even better performance and greater economies. Many of the new production assembly lines are designed after careful study of those already in operation, and include many small comforts which make the working conditions more pleasant. All safety requirements are observed so that accidents can be kept down to a minimum and the health of the men preserved. These items cannot be evaluated in dollars alone but they will contribute in a great degree.

By Morse Hill
Materiel Center
U. S. Army Air Forces
Wright Field, Dayton, Ohio

Tests on NE 8630 Steels for Welded Air Frames

THE FIRST of a series of reports summarizing the investigations on the steels which are proposed as alternates for the structural alloy steels now used in the aeronautical industry was printed in *Metal Progress* for September 1942 under the title "Suitability of Alternate Steels for Aircraft Parts". The second of the series, designated Serial No. 4799, Part II, extends the tests there reported to sheet samples, and summarizes weldability of sheet and tubing of NE8630. What follows will be confined to this aspect of the problem of utilization.

Briefly, the laboratory tests used for welding indicate that the technique used for welding X-4130 chromium-molybdenum tubing and sheet (specifications AN-WW-T-850 and AN-QQ-S-685) is satisfactory for this alternate steel NE8630 conforming to Aeronautical Material Specifications A.M.S.6355 for flat products and A.M.S.6530 for seamless tubing. These steels may be used interchangeably for welded structures, but each fabricator should determine that no difficulty will be experienced when the steels are welded in accordance with his established procedures.

Final evaluation of weldability will depend on the outcome of tests made by manufacturers of airframes and accessories on actual parts from production lines. It would appear, however, that steel tubing (A.M.S.6530) and steel sheet (A.M.S.6355) of NE8630 analysis, and chromium-molybdenum X-4130 steel may be welded together in an assembly, hardened from a temperature suitable for X-4130, and subsequently tempered by procedures recommended for either nominal composition. It appears that at equal draw temperatures NE8630 will have lower strength and greater ductility than X-4130, but results to date indicate that the variability in mechanical properties (including hardenability in the welded zone) between NE8630 and S.A.E.X-4130 is not greater than between the extremes of allowable compositions within either specification.

Three laboratory studies have been completed, one at the Materiel Center, one by Lockheed Aircraft Corp. ("Welding Tests on NE8630 Steels") and one by Boeing Airplane Co. (Report No. 6353, "Tests on Alternate Steels"). Since the findings are similar the results are summarized. Sheet and tubing having the chemical composition of the alternate steel NE8630 have been compared with similar sizes of X-4130.

The actual results have been summarized on the following pages in Tables I to V and Fig. 1 to 4. Welders find that sheet (A.M.S.6355) and tubing (A.M.S.6530) weld as easily as X-4130. The comments from the reports are:

1. The alternate steels melt somewhat faster and have a cleaner puddle of molten metal, especially in gas welding.
2. There is less tendency toward weld cracking in the alternate steels.
3. The hardness gradient and total hardness variation in the alternate steels compare favorably with X-4130. As shown by the figures, the hardness gradient from weld to base metal is often less steep in the alternate steels.
4. The welding techniques necessary are about the same for both types of steel.

Laboratory procedures used in testing at the Materiel Center are outlined below. The weldability of a steel cannot be completely determined by laboratory testing. It is essential that a number of parts representative of light and heavy sections be fabricated in the shops from several

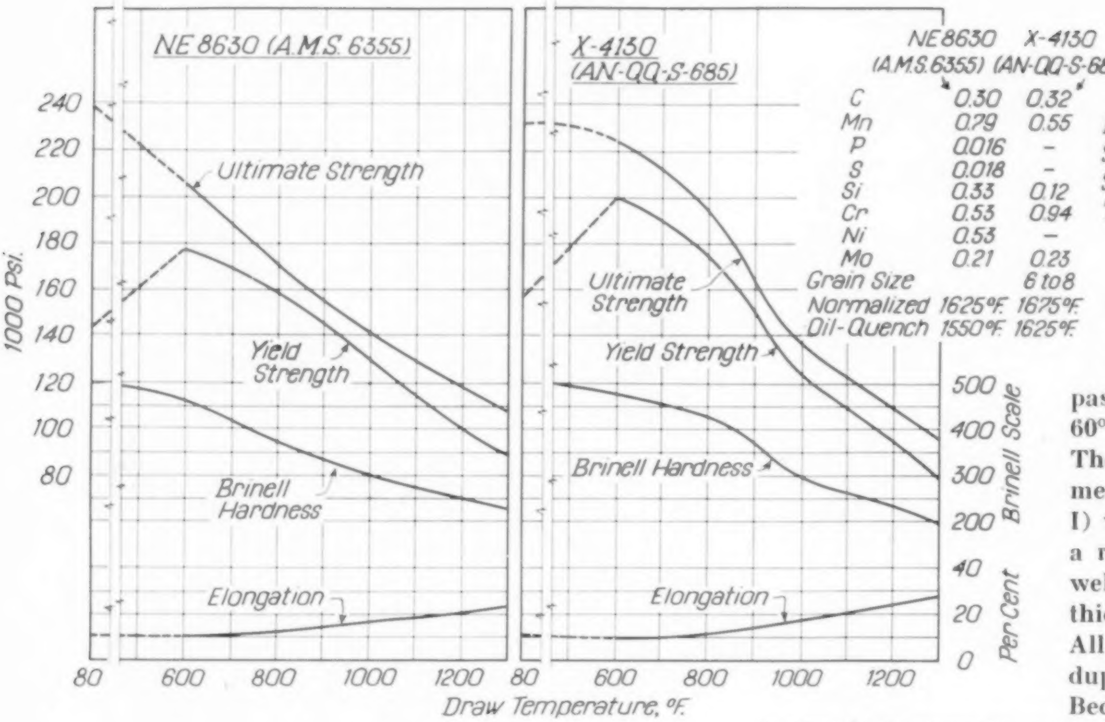


Fig. 1—Properties of a Single Heat of NE 8630 Steel, Heat Treated and Tested as ¼-In. Plate

heats of the alternate steel being considered. Each fabricator should weld a few trial parts from the alternate steel before changing over. No additional comment is made except to call attention again to the rather wide variations in hardenability among the standard steels, long used in aircraft structures.

Weldability — Butt welds were used exclusively. Except the ¼-in. plate, all were single pass welds. The ¼-in. plate was welded with a double pass and beveled to a 60° Vee before welding. The welded tensile specimens (results in Table I) were 14 in. long with a reduced width at the weld about six times the thickness of the sheet. All tests were made in duplicate or triplicate. Because it was the only typical high strength welding rod available at the Materiel Center, a Page Hi-Tensile welding rod was used.

Comparative tests on AN-QQ-S-685 (X-4130 steel) were also made in ¼-in. plate, and results shown in Table I and Fig. 1. In addition to the tests shown some specimens of 8630 plate were welded to X-4130. When arc-welded with heavily coated electrode the tensile strength was 94,700 psi., and failure was in the annealed zone of

Table I — Tests on NE8630 Sheet and Plate, and Butt Welds Made Thereof

Thickness	Welding Method	Treatment	Tensile Properties: Yield	Ultimate	Elongation	Vickers Hardness	Location of Fracture
0.036 in.	None	None	58,400	82,000	20	170	
	None	Normalized	66,500	132,800	13.7	239	
	None	Q. 1550°; d. 850°	167,600	173,700	4.6	390-481	
	Arc	As welded	....	84,400	12	See Fig. 2-A	Base metal
	Gas	As welded	....	87,200	11	See Fig. 2-A	Base metal
0.062	None	None	52,200	75,300	23.5	166	
	None	Normalized	69,800	129,000	15.8	302	
	None	Q. 1550°; d. 850°	176,500	173,000	6.4	377-480	
	Arc	As welded	....	78,300	14	See Fig. 2-B	Base metal
	Arc	*(a)*	....	108,500	10	....	Base metal
	Gas	As welded	....	81,200	11	See Fig. 2-B	Base metal
	Gas	*(a)*	....	104,600	10	....	Base metal
0.25	None	*(b)*	88,000	107,000	23	250	
(X-4130)	*None*	*(c)*	*94,000*	*109,000*	*23*	*185*	
	Arc *(d)*	As welded	....	107,200	3.5	See Fig. 2-D	In weld
(X-4130)	*Arc (d)*	*As welded*	....	*93,300*	*14*	*See Fig. 2-D*	*(f)*
	Gas *(e)*	As welded	....	104,500	4	See Fig. 2-D	In weld
(X-4130)	*Gas (e)*	*As welded*	....	*93,600*	*3.5*	*See Fig. 2-D*	*(f)*

(a) Normalized at 1650° F. and air cooled after welding.

(b) Normalized at 1625° F., oil quenched from 1550° F., drawn at 1300° F. See also Fig. 1.

(c) Lines in italic represent X-4130 (AN-QQ-S-685); normalized at 1675° F., oil quenched from 1625° F., drawn at 1200° F. See also Fig. 1.

(d) Heavily coated electrode used.

(e) Page "Hi-Tensile" rod used.

(f) Annealed zone in plate.

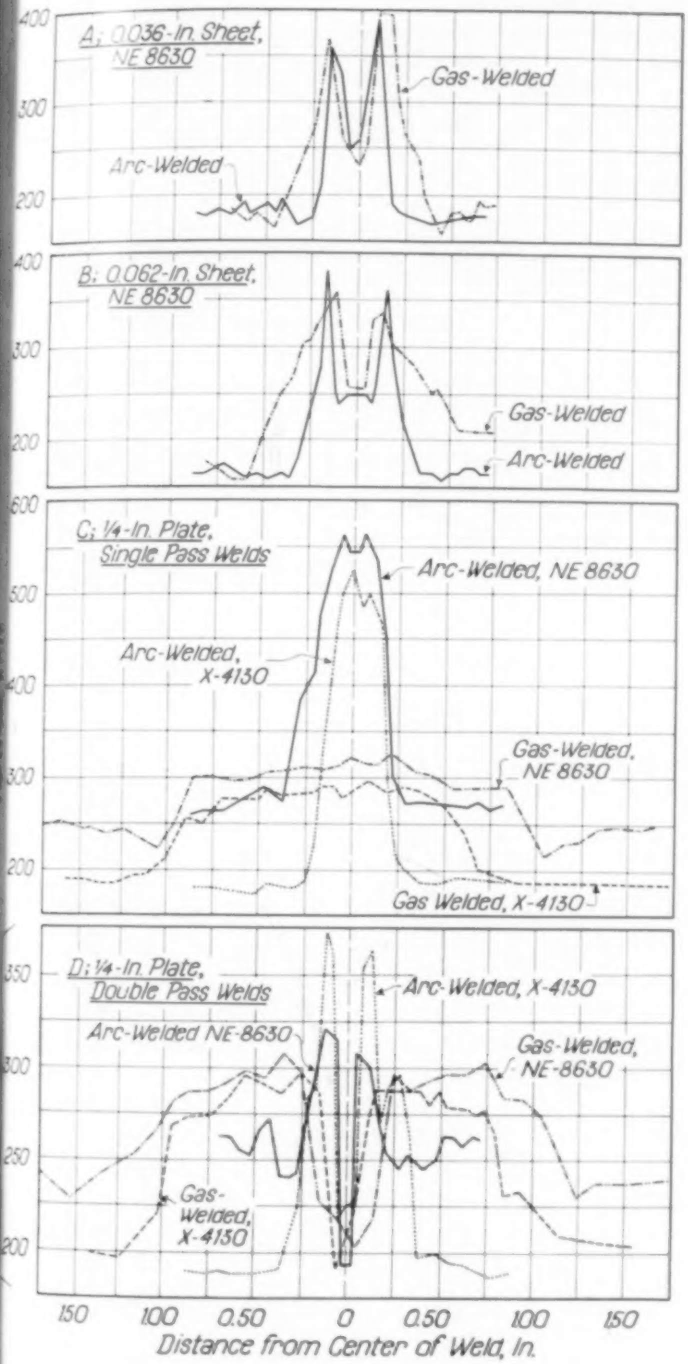


Fig. 2—Hardness Traverses of Butt Welds in NE 8630 and X-4130 Sheet and Plate

X-4130, which developed 14% elongation in 2 in., during which time the 8630 stretched 1.5%. When gas-welded with high-tensile rod the joint broke at 96,100 psi. in the weld; the X-4130 plate elongated 5% in 2 in. and was beginning to neck down.

Hardness surveys across these welded joints are shown in Fig. 2, in which the peaks are somewhat exaggerated by the vertical scale. These curves show that the maximum hardnesses of NE8630 and X-4130, when welded with the ordinary techniques, are on the same order of magnitude.

Tensile Properties

Returning to a consideration of Fig. 1, which compares data on NE8630 steel in the form of ¼-in. plate with X-4130 plate of the same thickness, X-4130 shows decidedly better strength with the lower drawing temperature. Furthermore, for the same strength it may be drawn to a higher temperature. This possibly might be advantageous if the maximum amount of stress relief were necessary. The figures presented are the average of four specimens, two taken longitudinally and two transversely to the direction of rolling. In general the longitudinal specimens showed from 3000 to 5000 psi. greater ultimate strength and about 3% greater elongation. (Elongation on these flat specimens is not directly comparable to elongation on round specimens. The same material tested as a flat specimen will have a lower elongation than if tested as a round specimen.)

Table II — Properties of NE8630 Seamless Steel Tubing Conforming to Specification A.M.S. 6530

Condition	1 in. x 0.036				1 in. x 0.062			
	Yield	Ultimate	Elongation	Vickers Hardness	Yield	Ultimate	Elongation	Vickers Hardness
As received	88,400	120,500	19.0	260	82,600	114,000	23.8	257
Normalized at 1650° F.	60,000	115,500	17.0	273	61,500	114,100	22.2	276
Normalized at 1700° F.	54,600	113,300	14.5	280	63,400	118,500	21.5	276
Normalized at 1800° F.	50,500	97,600	20.2	224	58,400	105,400	25.0	228
Quench 1550° F.; draw 1100° F.	128,300	132,400	13.0	288	126,400	133,200	17.0	302
Quench 1550° F.; draw 900° F.	155,700	158,800	8.5	355	160,200	163,400	16.5	380
Quench 1550° F.; draw 700° F.	180,500	186,500	5.5	432	184,200	196,400	8.7	450

Table III — Effect of Drawing After Normalizing

Tube Size	Normalized at 1650° F.			Drawn at 900° F., After Normalizing		
	Yield	Ultimate	Elongation	Yield	Ultimate	Elongation
	NE 8630 Tested at Materiel Center					
½ x 0.037	56,950*	111,600*	20*	82,420†	100,690†	22†
1 x 0.063	60,410†	107,900†	25†	80,300†	100,500†	26†
2 x 0.25	60,550*	95,500*	43*	68,900*	93,150*	27*
	X-4130 Tested at National Tube Co.					
¾ x 0.035	66,500	127,200	18	91,000	113,920	23
¾ x 0.035	76,000	117,600	17	88,500	112,600	15
2¼ x 0.25	69,200	103,000	36	75,700	104,200	37
2¼ x 0.25	63,460	94,580	43	63,380	95,040	42
	All stress-strain curves show a smooth curve of gradually increasing elongation (see Fig. 3)			All stress-strain curves show a definite break at yield, preceded by slight elongation (see Fig. 3)		

*Average of two determinations.
†Average of four determinations.

Table II gives somes tensile tests and Vickers hardnesses of 1-in. tubing made of NE8630 as tested at Materiel Center as received and after various heat treatments. Values for quenched and drawn tubing of sizes ranging from ¾ x 0.035 to 1.0 x 0.065, as determined by Boeing Airplane Co., agree fairly well with those listed in Table II. Table III compares such tubing with X-4130 (both conforming to the A.M.S. 6530 for seamless tubes) after normalizing, and after normalizing and tempering.

NE8630 tubing, when quenched and drawn, develops strength equal to the X-4130, but when normalized the yield strength is generally below that required by Specification AN-WW-T-850 for X-4130 tubing. This same phenomenon has been encountered at National Tube Co., Ellwood Works, in X-4130 steel, as noted in a report on March 25, 1940, showing the "Comparative Stress-Strain Curves in the Normalized, and Nor-

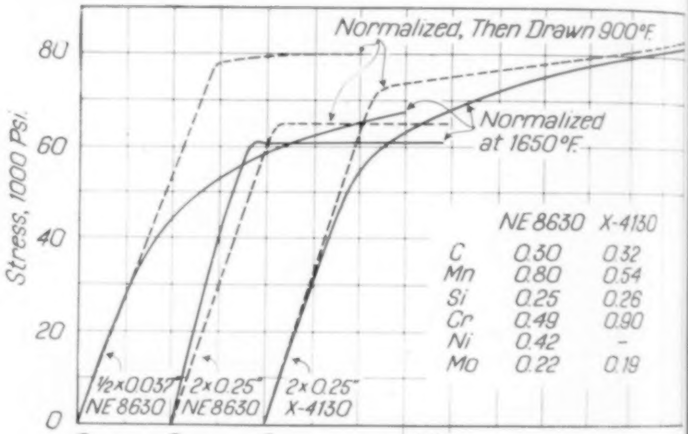


Fig. 3—Normalized Aircraft Tubing (NE 8630 and X-4130) Must Be Tempered to Develop Well Marked Yield Point

Table IV — Tests on Welded Tubing (Materiel Center)

Size	Weld	Rod	Heat Treated	Ultimate Strength	Elongation in 2 In.	Fracture
1 x 0.036	Arc	Low carbon	Yes	168,000	..	Both sides of bead
	Gas	Low carbon	No	113,000	6.5	In base metal
	Gas	Low carbon	Yes	173,500	2.5	In weld and base metal
	Gas	High tensile	No	111,000	7.5	In base metal
	Gas	High tensile	Yes	192,500	2	Diagonal, through base metal
1 x 0.065	Arc	Low carbon	No	113,000	6	In base metal
	Arc	Low carbon	Yes	176,000	2.5	Part in sound weld
	Arc	High tensile	No	109,000	8	In base metal
	Arc	High tensile	Yes	150,500	2	Through blowholes in weld
	Gas	Low carbon	No	113,500	8	In base metal
	Gas	Low carbon	Yes	142,000	2.5	In sound weld
	Gas	High tensile	No	107,000	6	In base metal
	Gas	High tensile	Yes	193,000	2	In base metal
2 x 0.25	Arc	Heavily coated	...	91,700	..	In weld } A few medium
	Arc	Reverse polarity	...	99,500	..	In weld } blowholes
	Gas	Low carbon	...	81,300	..	In sound weld
	Gas	High tensile	...	90,800	..	In sound weld
(X-4130)	*Arc*	*Heavily coated*	...	*109,100*	..	*In weld; a few medium blowholes*
(X-4130)	*Gas*	*High tensile*	...	*100,900*	..	*In sound weld*

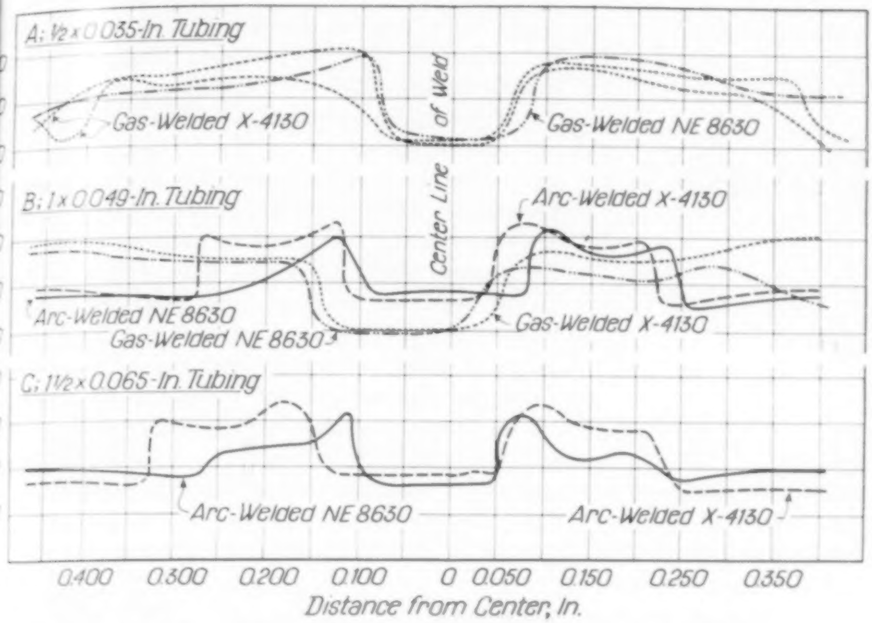


Fig. 4—Hardness Surveys Over Heat Affected Zones of Welded Tubing (Lockheed Aircraft Corp.). Measurements in 0.025-in. steps

nalized and Drawn, Conditions of Chromium-Molybdenum Aircraft Tubing". This was also shown by both steels in the 1/4-in. plate.

Generally, however, the alternate steel shows a slightly lower yield strength than X-4130 although this may be only a reflection of the lower carbon contents in the heats of the former with which this laboratory has had experience. Nevertheless the low yield strength should be considered in conjunction with design stresses whenever substitution is contemplated. However, by drawing the normalized tubing at 900° F., the yield strength may be raised without appreciably lowering the ultimate strength. This is accompanied by a change in the type of stress-strain curve as shown in Fig. 3. Comparative values are shown in Table III. This drawing operation seems to relieve internal stresses and eliminate unstable microconstituents.

Table IV shows some tensile strengths and elongations in 2 in. on butt welds made in seamless tubing, and a few comparisons with X-4130 in the larger size. Hardness surveys over the heat treated zones in the welded 1 x 0.065-in. tubing gave results very similar to those shown in Fig. 2-B, and in the welded 2 x 0.25-in. tubing to the double pass welds in Fig. 2-D.

Table V includes comparative tensile tests and maximum hardnesses on the Rockwell B scale, for butt welded tubing, welded with carbon rod.

Finally Fig. 4 gives some hardness surveys over the heat affected zones as welded and tested by Lockheed Aircraft Corp. These hardnesses are on the same order as those shown in Fig. 2, when the hardness ordinate is reduced to a common hardness scale. A rough correlation of hardness is as follows:

Rockwell A-50	equals Vickers	160
A-60		240
A-70		405
A-80		715

To test the tendency of the specimens to crack after welding, pieces of tubing were welded in the form of 18-in. equilateral triangles with a smaller inscribed equilateral triangle of 8-in. pieces welded at the centers of the limbs of the triangles. The flux was removed by pickling and the welds examined visually and with magnaflux for cracking. No indications were found.

Table V — As-Received Tubing, Welded With Carbon Rod by Boeing Airplane Co.

Tube Size	NE8630				X-4130			
	Tensile Strength	Elongation	Hardness Rockwell	Location of Break	Tensile Strength	Elongation	Hardness Rockwell	Location of Break
3/4 x 0.035	119,800	5.5	95	3/4	96,000	4.5	98	5/8
	119,800	5.5	96	7/8				
7/8 x 0.065	114,400	6.5	99	1 1/16	102,900	6	100	3/4
	98,000	4.5	100	In weld				
Normalized	*119,000*	*8*	*101*	*1 3/8*	*97,000*	*8*	*101*	*1*
1 x 0.065	113,000	6	101	1	108,500	7.5	98	7/8
	144,800	7	99	7/8				
1 x 0.097	122,500	6	100	7/8	107,200	5	102	3/4
	120,000	6.5	101	3/4				

Critical Points

By the Editor

RIDING A BLIZZARD out of Cleveland and, belated by frozen switches, arriving in subzero New York, there being much put out by the disorganized terminal staff and fleeting taxis, but later much rewarded by spending pleasant hours amid good friends, usually seen at these meetings, at the Mining Engineers' annual convention.... A day-long conference on non-ferrous secondary metals emphasized once again the difficulty in estimating the available tonnage. Such metal does not appear in most statistical totals unless it is shipped from one plant to another, yet it is clear that brass cartridge scrap sent from Western Arms where it is made, to Chase Brass where it is remelted, is as much "metal in process" as the crop ends recovered in Chase Brass's own plant. Took the attitude that the *only* addition to our supply of metal mined out of the ground is that which is recovered from demolition scrap or waste dumps — stuff that has been made long since and served its life in some now unnecessary duty. So many bad guesses have been made on the amount of demolition scrap that could be scraped together in a year that it would be unwise to make another. Certain it is, though, that systematic looting of occupied countries of everything down to the baby's pewter spoon has enabled Hitler to eke out his Wehrmacht's necessities, and, equally hard driven, we could wrench loose a mountain of copper, tin, lead and zinc. As things now are, America can expect a dwindling supply of secondaries from within its own borders, what with the lack of consumer's goods to replace junked metal, and what with the manpower shortage and the bureaucratic restrictions on the activities of the collecting industry. It behooves engineers and metallurgists, therefore, who are "degrading" the alloys used in necessary parts, to change the specifications to alloys as low in tin and as high in lead as possible, and to *do it now*, all at once, rather than in several halting steps....To a couple of meatless banquets, and depressed at the debased state of oratory imposed by the Censor upon such virile men as Rubber Director JEFFERS and Columbia Dean BARKER (now assistant to the Secretary of the Navy). They tried their best to breathe some fire into sophomoric platitudes. Glad, however, to see HERBERT HOOVER, graying but vigorous, and to subscribe to his plea for prompt and realistic national action to insure larger herds of livestock and larger plantings of foodstuffs, for it's now almost too late....Ten years of development in the laboratories of Radio Corp. were described by VLADIMIR ZWORYKIN in his lecture on the electron microscope (the annual Institute of Metals lecture). About 50 instruments of various designs are now working in laboratories here and abroad — not exclusively on metals, of course, but more frequently on transparent organic materials and chemical synthetics. For other purposes than the analysis of ultra-microscopic surface films, solids must be studied by making transparent replicas of their surfaces, and ZWORYKIN described four methods of doing this. The application of the electron microscope (which multiplies 100-fold the resolution obtained by best optical microscopes) may well be as epoch-making as Sorby's first use of the microscope in metal study, but so far, to this skeptic eye, electron microscope prints of metallic surfaces usually look like mere enlargements of micrographs. Many questions will arise as to how to interpret what you see in such a photo — for example, is a tiny spot a few atoms in diameter a crystal of a second phase, a locus of a localized strain, a "disordered" region where solute atoms are rather more concentrated, or a pore?....Talked with MYRON WEISS, erstwhile Science Editor for *Time*, recently returned from Portugal shepherding some unfortunate (or fortunate?) exiles. He found over there that Germans were everywhere, photographing everything, buying everything, flying away with pigs and silk stockings, telling everyone about mills at Essen, factories at Nuremberg, ships at Bremen. The Portuguese saw and heard, felt and smelt the Germans — a menacing reality. The Americans were mythical, unreal — until they pounced on Morocco. Then word came back of real tanks from Detroit, great ships from New Orleans, heavy guns from Springfield, fast airplanes from San Diego, ample food from Wisconsin, oil from Texas, bronzed men from the West shouldering their way East. An electric change in sentiment, for at last the Portuguese could see and believe what they fondly hoped were true!

Supply of non-ferrous scrap

Improved electron microscopes

Convincing realities

Properties of Important Wrought Chromium-Iron Alloys

Revised 1943, from data furnished by U.S. Steel Corp., Electro Metallurgical Co., and Commitee A-10, A.S.T.M.

Nominal Alloy A.I.S.I. Type No.	2% Cr —	5% Cr 502	9% Cr —	12% Cr 410; 416	Cutlery 420	17% Cr 430	27% Cr 446
Chemical composition							
Chromium	1.75 to 2.25	4 to 6	8 to 10	10 to 14	12 to 14	16 to 18	23 to 27
Molybdenum	0.6	0.5	1.0 or 1.5	(0.6 max.)	—	(0.5 max. Ni)	(1.0 max. Ni)
Mn (max.)	0.65	0.50	0.5	0.5	0.55	0.5	1.5
Carbon	0.15 max.	0.10 to 0.20	0.15 max.	0.15 max.	0.30 to 0.40	0.12 max.	0.35 max.
Specific gravity							
Lb. per cu. in.	—	0.28	0.282	0.28	0.278	0.277	0.273
(Mild steel = 1.00)	—	0.99	1.00	0.98	0.98	0.98	0.96
Resistance at 70°F.							
Microhms per cm³	—	35	—	57	60	60	67
(Mild steel = 1.00)	—	3.2	—	5.2	5.5	5.5	6.1
Melting range, °F.							
Top	—	2800	—	2790	2750	2750	2750
Bottom	—	2700	—	2700	2580	2700	2700
Structure (normal)	Pearlitic	Martensitic	Martensitic	Martensitic or Ferritic	Martensitic	Ferritic	Ferritic
Magnetism							
Ferromagnetic	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Permeability: As annealed	—	—	—	—	—	—	—
Permeability: Cold worked 10%	—	—	—	—	—	—	—
Specific heat							
C.g.s. units, 0 to 100°C.	0.11	0.11	0.11	0.11	0.117	0.11	0.12
(Mild steel = 1.00)	1.0	1.0	1.0	1.0	1.1	1.0	1.1
Thermal conductivity							
* C.g.s. units at 100°C.	—	0.0874	—	0.0595	0.054	0.0595	0.0500
(Mild steel = 1.00)	—	0.73	—	0.50	0.45	0.50	0.42
C.g.s. units at 500°C.	—	0.0804	—	0.0686	—	0.0624	0.0581
Thermal expansion per °F. x 1,000,000							
From 32 to 212°F.	—	6.2	6.2	6.1	5.7	5.6	5.9
(Mild steel = 1.00)	—	0.94	0.94	0.93	0.87	0.86	0.90
From 32 to 932°F.	7.3	7.2	6.9	6.7	6.6	6.7	6.3

Mechanical Properties at Room Temperature	2% Cr Annealed	5% Cr Annealed	5% Cr Quenched (1600°); Tempered (1000°)	9% Cr Annealed	12% Cr Annealed	12% Cr Quenched & Tempered (800-1300°)	Cutlery Annealed	Cutlery †† Heat Treated	17% Cr Annealed	17% Cr Cold Worked (Wire)	27% Cr Annealed	27% Cr Cold Worked (Wire)
Tensile strength, 1000 psi.	60 to 70	65 to 85	175	70 to 87	65 to 85	90 to 180	90	230 to 260	70 to 80	90 to 110	75 to 95	85 to 175
Yield strength, 1000 psi.	30 to 45	30 to 60	145	35 to 45	35 to 45	70 to 160	65	200 to 220	40 to 50	80	50 to 60	55 to 155
Elastic modulus, 10^6 psi.	29	29	—	29	29	29	29	—	29	—	29	—
Elongation, % in 2 in.	40 to 30	45 to 35	17	40 to 25	35 to 25	25 to 15	27	5	30 to 25	25 to 8	30 to 20	25 to 2
Reduction of Area, %	65 to 45	75 to 60	60	70 to 50	65	65 to 45	59	7	75 to 50	70	60 to 50	55 to 25
Impact, ft-lb., Charpy	35 to 65	45 to 75	—	45	—	—	—	—	—	—	—	—
Impact, ft-lb., Izod	—	75 to 85	32	90	100 to 60	20 to 30	65	—	—	—	2	—
Fatigue endurance limit, 1000 psi.	—	—	—	—	43	55	50	—	34	50	50	—
Hardness, Brinell	130 to 160	135 to 180	300	145 to 180	135 to 165	180 to 380	190	480	175	197	160 to 190	150 to 250
Hardness, Rockwell	—	B-75 to 85	C-24	—	B-80	—	B-90	C-54	B-80	B-97	B-85	C-0 to 25
Erichsen value, mm.	—	—	—	—	7 to 8	—	—	—	7 to 9	—	—	—
Olsen value, In.	— 0.375 to 0.450 —			—	—	—	—	—	—	—	—	—

	2% Cr	5% Cr	9% Cr	12% Cr	Cutlery	17% Cr	27% Cr
Stress in psi. causing 1% "creep" in 10,000 hr. at 1000°F.	11,000	9,000	11,000	12,000	4,500	8,500	6,200
1100	5,500	4,500	6,950	4,700	1,700	5,000	3,000
1200	3,000	2,100	2,400	2,200	1,300	2,100	1,600
1350	—	—	—	1,400		1,000	400
Scaling temp., °F.	1100	1,150	1200	1,250	1,250	1,550	2,000
Initial forging temp., °F.	2200	2,100 to 2200	2000 to 2150	2,000 to 2,100	2,000 to 2,100	1,900 to 2,050	1,900 to 2,000
Finishing temp., °F.	1500	1500 to 1600	1600	1,500	1,700 to 1,750	1,500	1,300 to 1,450
Annealing treatment	†	†††	***	**	Cool from 1,450 to 1550	Air cool from 1,400 to 1,450	Rapid cool from 1,450 to 1,550

* Thermal conductivity is measured as calories per sq. cm. per sec. per °C. per cm.

†† Oil quenched from 1850°F. and tempered

** Furnace cool from 1550 to 1100°F., or air cool from long heat at 1250 to 1350°F.

*** Cool from 1325 to 1375°F. or slow cool from 1600 to 1675°F.

††† " " " " " " " " 1525 to 1600°F.

† Furnace cool from 1620°F.

ONE of the best attended of the Group Meetings on War Products held during the last annual convention was on "Practical Programs for Segregation, Collection and Reclamation of Metal Scrap" (or "Recoveries" as they have been more aptly termed). So much has already been said in the popular scrap "drives" that it might be thought that the need has been filled, or at least that the available scrap has all been reclaimed. Such is far from true. Public scrap drives recover relatively little scrap in comparison with the enormous tonnage of by-products from manufacturing operations. *This* is the subject matter of the present series of articles, and is the most important source of re-usable material.

Doleful predictions that the 1942 production of steel would lag badly because of scrap shortage were not true, principally because the nation's junk men did an unexampled job. Nevertheless the need is continuous, not only for iron and steel, but also for all manner of non-ferrous "recoveries". Those who have *not* neglected the matter can get useful ideas from what these five experts say. Others who *have* neglected the matter may derive therefrom the final push to get busy, for Hitler wants your scrap to remain idle, or get mixed up and next to useless.

A very good "Primer of Industrial Scrap" will be sent you gratis if you write the Industrial Scrap Committee, 3303 Empire State Bldg., New York.

Practical Programs for Reclamation of Metal Scrap

Steps to Minimize Amount of Scrap Produced

By J. L. Cannon
Assistant Chief Metallurgist
Hyatt Bearings Division of General Motors

STEPS TO MINIMIZE amount of scrap in process start with the purchase of raw material, which should be specified to a quality and precision no greater than required by the service of the part to be made therefrom. Further considerations are based on the shop equipment available; materials that form or cut easily (other things being equal) produce the fewest discards.

Much also goes back to tool design. Drawing or forming dies should not cause excessive mechanical working and failure of the metal, despite intermediate anneals. Pressure pads in initial draw operations help control movement of metal and will often prevent folds or laps.

Blankings should be positioned to produce maximum number of parts per section of material. Multiple blanking would further reduce skeleton waste. Closer width tolerances — total tolerances, all plus or all minus — or use of mill sheared edge stock, for example, would minimize waste. Cold rolled stock may be justified to minimize subsequent stock losses through added grinding or other operations. Cut lengths in exact blank multiples prevent excessive butt-end waste. Use of coils rather than cut lengths further minimizes butt-end waste, as does increasing coil weights within practical mill and production equipment limits, and the welding of coils, end to end in a continuous piece.

Ring centers, cup bottoms, or other blank forms often classified as scrap from some previous operation may be usable for a similar part of smaller dimensions, or can serve as material for another part produced by a different method. Any final butt-end scrap should also be considered in this category.

Structure and hardness of cold heading materials are of utmost importance to insure satisfactory cut-off and quality. Size is important to reduce any waste of material through unnecessary end grind operations, or early die failures from heavier blows required to reduce the part cold. Slight reductions in size of raw material may reduce the flash, minimizing, thereby, stock losses through clean-up operations.

Materials for machined parts should be of such form as to produce the minimum of chips. Nature of tubes or bars, that is, hot rolled, rough turned, cold drawn or centerless ground, should be specified with the idea of minimizing the amount of metal removed for clean-up of part. Critical or working surfaces, as compared to non-working surfaces, should be further reviewed and tolerances specified to insure that metal is removed only where necessary. Proper heat treatment and conditioning to give best in machinability are important, both from the standpoint of resultant automatic finishes as well as to give added tool life.

Butt-end waste from long lengths can often be reduced by moving the cut-off tool closer to the machine spindle — also by using electric shut-off switches, which not only give better insurance against tool breakage but may permit the operator to make an additional part by hand feeding. Plug adapters to feed tubing through chucks will sometimes produce an extra part, or an additional part can be made from butt-end scrap by machining the individually chucked part. Or an additional part similar in dimensions excepting length can be produced. Butt-ends, brazed together, are useful for machine set-ups, thus minimizing waste metal through this necessary operation. Chuck design and chucking methods should be reviewed to prevent distortion, necessitating added stock allowance for clean-up. Full complement chucks or chucks with jaws designed to cover most of the area supported are helpful in this respect.

Sizable reductions in scrap can often be made by redesign of the cutting tool, which not only reduces the amount of chips but the number of inspection rejects, as well as conserves the critical toolsteel alloys. This matter is a subject in itself, and cannot be elaborated now in the time at my disposal.

Production operations in general must be rigidly controlled and observed to prevent mistakes or poor workmanship, resulting in rejected parts. Improperly trained or instructed operators make mistakes; others result from sheer carelessness. On the other hand, poor operating practices are either overlooked, or sometimes accepted as being unavoidable and the corresponding waste in materials is tolerated. Defective equipment, equipment in poor condition, or equipment of wrong design becomes a major source of rejected or scrapped parts.

Movement, or flow of production parts from machine to machine, operation to operation, or department to department, in containers, conveyors or other transport should be carefully reviewed to avoid loss and mix-ups. Machine sumps and chip chutes should be critically inspected to prevent loss of parts; quench tanks, washing machines, parts hanging up on belts or in furnaces — all these are hiding places for lost parts and should be modified to prevent accumulation of scrap from these sources.

Program for a Medium Sized Plant

By E. S. Hoopes, Jr.
Assistant General Superintendent
Steel and Tube Division
Timken Roller Bearing Co.

THE PROBLEM of suitable organization for handling metal scrap in a medium sized plant requires study of two fundamental factors:

1. *The Type of Manufacturing Plant* whether it is a primary metal producer engaged in melting and rolling, or is a fabricating plant producing scrap by machining, forming, or other metal working operations. By far the larger number fall in the fabricating group. They represent our largest source of raw scrap under war production, and it is essential that these plants establish effective means for segregating and collecting it.

2. *The Type of Scrap Produced* in relation to its basic composition, whether non-ferrous or ferrous material, either commercial metal or alloy in any of the numerous grades.

After analysis is made of the situation which prevails in a particular plant, the organization needed to carry out the scrap program effectively can be developed.

Organization — Experience indicates that the establishment of a scrap or salvage department headed by a supervisor with full authority to act produces the best results. The individual selected to manage this activity should have a thorough knowledge of the plant operation and its products. He must enlist the full cooperation of all department supervisors and foremen. If the plant has a complex scrap problem it may be desirable to appoint an advisory committee to assist in making policies, and to clarify the objectives of the program. Steps that are desirable for the

salvage manager to take in organizing his department are as follows:

1. Train employees to know the types and nature of scrap, so as to insure proper segregation.

2. Develop an organization capable of collecting and transporting such material.

3. Obtain equipment for handling and preparation of this collected scrap.

4. Provide adequate storage facilities.

5. Acquaint the plant personnel with the need and economics of salvage.

6. Establish a system of periodic records, and reports on scrap collected and sold.

As a specific illustration, let us take a plant fabricating highly finished parts from different grades of alloy steels.

Segregation and Collection — Training is required to familiarize the personnel producing and handling the scrap with the different kinds and grades. Scrap can be segregated and identified most successfully at the operation where it is produced. This requires some knowledge by automatic screw machine operators, machinists, punch press operators, tool makers, and other workmen, to prevent mixing or contamination. To simplify this problem a uniform system of identification should be adopted. Paint colors and letters to identify the different grades in physical form have been established. Thus:

Letter Symbol	Paint Color	Nature of Alloy
A	Red	S.A.E. 4600; Ni-Mo
B	Red and blue	S.A.E. 4300; Cr-Ni-Mo
C	Blue	S.A.E. 1000; Carbon S.A.E. 1300; Mn
D	Green	S.A.E. 2000; Ni S.A.E. 3000; Ni-Cr
E	Yellow	S.A.E. 5100; 52100; Cr
F	White	S.A.E. 4100; Cr-Mo

In this case the number of classes has been limited to six in order to make the identification system easily understandable. Scrap containers color banded and letter labeled to indicate the type of metal have been placed at convenient points, and the method of identifying scrap is followed through all operations.

The plan for scrap salvage is divided into two methods of collection: The "campaign" type which spotlights the recovery of dormant scrap in the form of obsolete machinery, discontinued finished parts, old dies, jigs and fixtures not in use, the mining of metal dumps, and a multitude of miscellaneous items. The mining of dumps has proven to be a rich source of scrap in many cases. Where the company has been long established it may find that more than one such dump has grown up. This kind of scrap collection is good as a "once only" measure with advantages in plant clean-up and impressing the employees with urgent need of the program.

The more important "long-term method" is the collection of production scrap. Using the same plant for illustration, this scrap will be in the form of automatic machine turnings, boring mill turnings, punchings and stampings, machine shop chips, rejected parts, and metallic grinding compound. Since the machine turnings are mostly in light form they are collected in chip-buggies and wheeled to a conveyor which carries them to a washer where oil is removed. Other classes of scrap are collected in tote boxes and delivered to separate storage bins by electric lift truck. When sufficient quantity is gathered it is loaded by magnet into railroad cars and sent to melting furnaces or steel plant scrap storage yard. Stainless steel, alloy toolsteel and non-ferrous scrap is collected in barrels or buckets marked for identification. Even toolsteel grindings from tool rooms are a valuable high grade "ore" of tungsten, molybdenum and chromium.

This scrap is delivered to the salvage department where it is placed in storage bins to be sold to refiners for cleaning and recovery.

Waste wardens have been appointed to serve in various sections of the plant and serve as policemen for collection and segregation of all salvage material.

Handling and Preparation — Various types of equipment are needed to do a good job, such as well-designed containers, lift trucks, auto trucks of "load-lugger bucket" type, monorail crane or bridge cranes equipped with magnet, and even narrow gage railroad. All these have a definite place in a salvage program, depending on the plant layout and the nature of its activities. Trucks equipped with lifting mechanism to handle load-lugger buckets are very satisfactory to get at many operations not serviced by a crane.

Preparation of scrap involves putting it in a form suitable for charging in melting furnaces or cupolas. A small plant can put this job on the shoulders of the scrap dealer or middleman. A larger plant may economically do it, if it delivers scrap directly to a remelter. Cutting scrap to required lengths is necessary for its use in electric or openhearth furnaces. Lighter sections and small diameter material can be cut with an alligator shear. Large scrap is cut by oxy-acetylene torch.

Until recent years machine turn-

ings were not considered desirable scrap for steel melting furnaces. This opinion has rapidly changed with the shift from civilian to war production, the growing shortage of available heavy scrap, and the tremendous expansion in machining operations. This has led to the use of the briquetting machine, such as shown on the opposite page, which compresses the turnings into heavier, denser form easily handled and stored.

In the Timken bearing plant, turnings are conveyed from the chip washer to a storage pit in the briquette building. There they are picked up by magnet, deposited in a bin from which they are fed into the machine hopper, crushed and compressed into briquettes weighing approximately 20 lb. each, 8 in. in diameter and 5 in. thick, having a density of 45 to 55%. Since oil is objectionable in electric furnace melting, it is necessary to burn the remaining oil out of the briquettes by putting them through a continuous gas furnace. Briquetting equipment not only prepares the scrap better, but also has proven of value in our associated steel plant over a period of years in recovering the contained alloy present in the turnings.

To obtain greatest efficiency from briquetting equipment a minimum of different analyses should be handled. Avoid loss of production in shutting down the machine to clean out all turnings and to change to another grade of material.

Storage Facilities should be adequate. Bins, boxes, and barrels for different types of scrap should be provided for temporary storage until sold or larger quantities collected. Many plants of moderate size will produce scrap in sufficient volume to require a storage yard in which final sorting and preparation for use or sale will be performed. Gantry, or bridge cranes, diesel locomotive or crawler cranes equipped to use magnet or grab bucket are all suitable equipment for the storage yard, depending on quantity and form of the scrap handled.

Reports — The salvage department should establish accurate scrap records from which reports will be made periodically to show its performance. Records showing the weight collected by type and grade of scrap, value of metal sold, and cost of operating the department are needed to justify its importance. Complete records are also required to comply with government regulations and to make the necessary reports.

If a well-organized program is put in operation and aggressively followed, it will produce results which will prove to be of economic value to the management, in addition to filling the pressing need of supplying metals to our hungry furnaces.

Salvage in a Large Industry

By Frank D. Kent
Supervisor of Surplus Materials
Wright Aeronautical Corp.

So far as most very large industries are concerned — particularly those in metal-working fields — the lowly scrap pile has come up in fame and importance as fast as any Horatio Alger hero. In proportion to this fame and importance, large plants have found it necessary to organize facilities to handle the salvaged material. Starting from scratch, the problem of coping with this scrap pile in wartime divides into several principal subjects:

First, the scrap must be identified and segregated; second, it must be moved as quickly as possible to a central receiving depot; third, it must be routed back into the channels of useful war work without delay, yet with due regard for efficiency and economy to the extent that partly loaded trucks or trains ought not to be dispatched. The fourth phase of the problem is one which to a great extent embraces the first job of identifying and segregating the scrap, although it has its bearing upon other jobs as well. This is educating and publicizing every last person with the vital necessity of avoiding scrap contamination, avoiding throwing it away as waste, and avoiding unnecessary delay.

Let me give you some of the highlights about the plan for salvage control set-up at Wright Aeronautical Corp., manufacturers of aircraft engines. The old bromide about the garbage man knowing the finances of everybody in the neighborhood by the contents of their garbage pails can be modified to apply to our business. Before the war, manufacture of aircraft engines was on a "custom-built" basis with comparatively few engines moving into the aviation industry each month. Today, along with other firms in aviation building, Wright Aeronautical has grown to many times its original size, and the problem of handling salvageable materials has grown almost in direct proportion. I say "almost" because technical improvements constantly being worked into the manufacturing process have reduced the amount of scrap normally made, but still there is sufficient work to keep many hands busy and to necessitate a salvage yard with thousands of square feet of storage space.

Wright Aeronautical had this head start in handling its scrap problem: For several years a salvage control system had been operating under the production department. (It was later trans-

ferred to become the surplus material section of the company's sales and service department.) Primarily this system was set up not to save critical materials, but rather to practice economy in regaining some of the investment represented by broken tools, chips, and shavings. This salvage control system, however, was a very useful nucleus for expanding the salvage facilities as the need became evident.

To fit this salvage control organization for a large-scale job, cooperation of other departments was obtained to an extraordinary degree. The engineering department has contributed, for example, by developing a synthetic sand for foundry molds which can be reclaimed and re-used. Another important contribution has come from the simplification of specifications: 90% of our aluminum alloys used to be made in six different alloys, but now they are made in *two* standards. The production department had a large share of the job in spreading to supervisors and machine tool operators the message continually reiterated: "Do not mix different types of scrap!" Public relations assisted by publicizing the need for segregation of scrap in the plant newspaper, the company magazine, and in local papers; posters were also made to put across the salvage message. The personnel division contributed by telling new employees of the need for avoiding scrap contamination.

Iron and Steel Turnings Do Not Stand Long Idle in Westinghouse's East Springfield Plant. Degreased and washed, they are compressed into 2-lb. briquettes in this press, 1000 per hr., and roll along, back to cupola or electric furnace

All of these cooperating departments worked right along with the salvage control organization *constantly*, rather than spasmodically in so-called "drives". The result has been not only an increasing volume of scrap but an increasing proportion of salvageable material to the comparatively small amount which cannot be saved.

In segregating scrap the major difficulty arises at the machine tools. We already had our salvage problem well in hand in the foundries, because in the aluminum foundry metal scrap was all aluminum; in the magnesium foundry it was all magnesium. Much scrap never gets out of these departments, but is reclaimed in their own remelting furnaces. Some foundry metal becomes substandard in processing and cannot be re-used in the manufacture of engines, so it is sold through channels set up for other metal scrap.

At the machine tools the job was partly one of education and partly one of systematizing. It was education to the extent that operators had to be told why a mixture of different kinds of metal was sheer waste. The job was one of systematizing to the extent that a simple system of tagging the types of scrap had to be organized and enforced. We use tags which give each kind of metal scrap a differently colored letter V. Nearly all our tools operate on a single type of material, if not on a single operation, so these "V's" are attached to each of the machines; a black V for stainless steel, and a red and blue V for phosphor bronze, etc. In collecting scrap from the machine tools, the scrap collector needs only to match the colors of the V on the machine tool with those on the collection boxes he wheels, to know when to stop and fill his box. The scrap stays with these differently colored "V's" right through to the point at which trucks from salvage companies pick up the chips and shavings from the loading platform of the salvage bins. These salvage bins represent the final stage in salvage control so far as Wright Aeronautical is concerned. There is a different bin for each type of chips and shavings — also a different outlet

for each type of metal from the loading platform.

Salvage control, to be sure, does not stop at metals, though this is probably the most vital part of our job right now. Other important phases include salvage of lubricating and cutting oils. The company has installed several oil reclaiming stills to separate the oil from impurities and put it back to useful work. We use centrifuges to whip cutting oil out of steel turnings and thereby, in a sense, do two salvage jobs at one time.

Broken cutting tools and drills are other important items on the salvage list, particularly in view of the critical situation in high speed steels. These cutting tools and drills were once disposed of as scrap at the market price per pound. Now, so far as possible, we pick out those tools which may be useful to war plants with production requirements less exacting than those for aircraft engines. The balance of this material too far gone for any manufacturing use is taken by steel mills for remelting.

Other material that is saved in great quantities by the company's salvage control system includes paper, cardboard boxes, burlap bags, kegs, barrels, worn files, grinding wheels, rubber mats used in Wheelabrator machines, old storage batteries, sheet lead, and rubber. As a public service, the company also arranged to handle tin cans brought in by employees.

Throughout all of these salvage jobs at Wright Aeronautical, it must be emphasized that the salvage control system is not a static thing. It cannot sit back and depend upon established system and procedures to do the job. Salvage "monitors" must be circulating throughout the production departments constantly to see to the enforcement of scrap segregation rules. Salvage specialists must be constantly studying the market to discover where scrap material can be put to best advantage outside the plant in the war effort. Salvage control also must plan for the future and anticipate the requirements for tomorrow just as the production departments must do.

The question that arises naturally in the minds of hard-pressed industrialists is one of practicality. Is the cost and the manpower expended on salvage work worth the results?

We think it is. A most important but nonrecurring economy appeared early in the program. In salvaging obsolete and obsolescent machine tools, dies, fixtures and stores we cleared away enough floor space to make a sizable contribution in those days when our plants were expanding rapidly. As to the continuing program, in the last 12 months, Wright Aeronautical recovered and put back into the war program more than 11,000 tons of all kinds of metals.

Modern Chip Handling

By Arthur M. Perrin
President, National Conveyors Co., Inc.

THE PROBLEM of chip handling is to transfer material from the cutting machines to storage hoppers, or railroad cars for removal from the plant, or to bale or briquette the material for consumption in the company's own foundry or melt shops. Broadly speaking, this involves an analysis of the material to be handled, an efficient method of segregation and of routing material through the plant, of processing the scrap by crushing, oil extracting and briquetting, and a proper provision for conveyors and storage facilities. Materials to be handled are usually as follows:

Cast iron borings, generally produced in a granular form, weighing approximately 120 lb. per cu.ft. They are easily handled, and seldom require any processing other than screening to remove shop waste. Oil may be removed to recover its value, although it does not usually harm the chips for cupola melting.

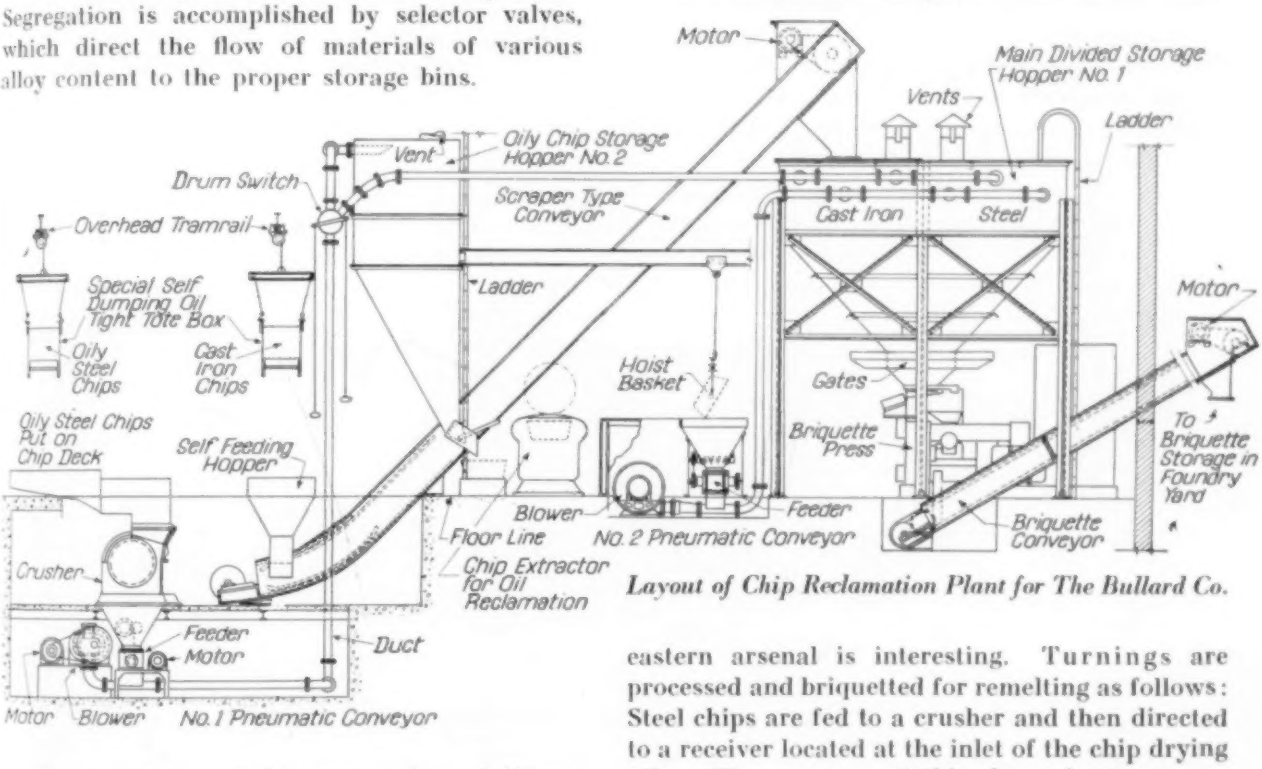
Steel turnings can be classified into two groups. The first will consist of small chips as from screw machine stock, not too difficult to handle since they are quite uniform in size. These weigh 80 to 125 lb. per cu.ft. The second consists of long turnings that, by their very nature, tend to snarl, are bulky, and vary in density from 10 to 30 lb. per cu.ft., very difficult to handle, and must somehow be reduced in size to untangle and increase the density to approximately 80 lb. per cu.ft. Increase in weight permits efficient truck and rail transportation, and the elimination of snarling will permit storage in bins, and facilitate unloading. In addition to crushing, extractor equipment should be included to reclaim any mineral oil used in cutting.

The first step to consider, when handling either steel or cast iron chips from cutting machines to the chip department, is that of proper segregation. The value of any lot of chips will be the unit price of the most inferior metal in the lot. Once turnings are contaminated or mixed with other materials, they cannot be efficiently separated. Therefore, segregation should take place at the cutting machine, by providing plainly labeled tote boxes, so that the sweeper or operator will be certain that the chips are originally placed in the proper containers.

Tote boxes should be arranged so they may be transferred through the plant by standard industrial lift trucks. Top corners should be

fitted with support plates to permit safe stacking of boxes and provision made for self-dumping of material.

These various factors have been successfully combined into efficient chip handling systems, as in one installed at The Bullard Co. of Bridgeport, Conn. The problem at this plant was to design a conveyor system that would correlate the chip crusher, oil extractor, and briquette press so that all equipment could be operated with a minimum of labor, enable the various types of metal to be segregated, and provide for future increases in production. After considerable investigation, it was decided that the pneumatic type of conveyor would best suit these requirements, as it is flexible in application, the space requirements are small, and changes of direction are easily made. Segregation is accomplished by selector valves, which direct the flow of materials of various alloy content to the proper storage bins.



Layout of Chip Reclamation Plant for The Bullard Co.

The operation of this system is as follows: Steel chips are manually fed through the crusher. If they have been machined with mineral cutting oil, the chips are pneumatically conveyed to a storage hopper serving the oil extracting equipment. When the oil is removed, the chips are transported through another pneumatic conveyor to the proper compartment in bins serving the briquetting press. Steel chips machined with soluble oil are conveyed directly from the crusher to their proper compartment in this storage hopper, while cast iron chips are dumped into a self-feeding hopper, screened, and delivered by scraper conveyor to the cast iron compartment.

Material from all compartments in these storage bins flows as wanted by gravity to the briquette press. Finished briquettes are conveyed to storage in the foundry yard.

This plant is operated with a crew of three men per shift, has a material handling capacity of six tons per hour, and can briquette material at the rate of three tons per hour. The pneumatic system has proven entirely satisfactory, and has been free from maintenance problems.

Several more-or-less standardized arrangements are available for handling metal turnings and borings, depending on the nature of the material to be handled. For instance one line-up is able to transport crushed aluminum chips weighing approximately 20 lb. per cu.ft. from storage space to railroad box car, whereby one operator can load a car in three hours.

The chip handling system installed at a large eastern arsenal is interesting. Turnings are processed and briquetted for remelting as follows: Steel chips are fed to a crusher and then directed to a receiver located at the inlet of the chip drying kiln. The purpose of this dryer is to remove cutting compound. This is important, as a clean product is required by the electric steel furnaces. Chips from the dryer outlet are conveyed pneumatically to any one of five storage bins, from which they are gravity fed to briquette presses. Briquettes are conveyed to large tote boxes set handily nearby, and then removed to storage. Cast iron chips are fed through crusher, and directed by means of selector valve to a proper section of the storage bin. This entire plant can be operated by four men, and has a capacity of approximately eight tons per hour.

The description of the various systems has necessarily been brief, but I trust gives some new ideas on the subject of modern chip handling.

Disposal of Recoveries

By H. J. Beattie
Apparatus Mfg. Department
General Electric Co.

When I received the invitation to speak on the "Disposal of Recoveries", I read the title several times before I understood it. For years we have been looking for a better sounding word for *scrap*. We have used "salvaged materials", "marketable waste products", "by-products", and other words. But now "recoveries" really places scrap on the plane it deserves!

General Electric Co. is recovering waste metals at a rate of one million pounds per day, seven days a week, 52 weeks a year. An average of 14 carloads of metal is shipped to mills, foundries, and smelters every day. By weight approximately 90% of the total is steel and iron and 10% non-ferrous, but on a value basis, the steel and iron represent only 40% and the copper, aluminum, tin and lead are worth 60% of the returns.

Eight fundamental principles or policies govern the disposition of our recoveries. They are:

1. Avoidable wastes are disposed of once and for all by taking steps to correct the conditions leading to such wastes.
2. The quantities of scrap generated largely govern the method of recovery and the disposition.
3. Recoveries are disposed of promptly.
4. As much of the recovered metals as possible are re-used in our own operations.
5. We arrange for the conversion of as much of the waste materials as possible on a returnable metal, "toll agreement" basis.
6. We sell the balance on competitive bids.
7. We sell on analysis or specification, not on wits.
8. We cooperate with W.P.B. on recommended segregations and allocations; with O.P.A. on prices; and O.D.T. on maximum car loadings.

Collection Yard for Metal Recoveries at a General Electric Plant in Pennsylvania. Salvage department uses these bins to hold various kinds of iron, steel, and alloy scrap, prior to shipment. Yard is 75 x 325 ft., and is commanded by a 20-ton crane

I will enlarge briefly on these eight points as time and space will allow.

Avoidable Waste is the responsibility of an organization in our company, quite distinct from the salvage group. Design engineers, draftsmen, and methods men at each of the company's plants constantly are developing new ways of reducing the amount of materials necessary in manufacture.

Paralleling these efforts is the suggestion system from which have come many excellent plans from workmen, resulting in material savings on specific jobs or operations.

Citing one example, stator frames of propulsion motors for cargo ships and tankers are fabricated from steel plate 1 to 1½ in. thick. Steel plate, as you well know, is a critical material, difficult to obtain. A clever nesting layout on the plates prior to gas cutting the segments that go to make up the frames for these motors was suggested by one of the men in the fabricating department. It resulted in a 15% reduction in the amount of material required for one design and a 25% reduction in another, with a net saving in steel plate of 700,000 lb. or 10 carloads per year. It involved a slight increase in labor for welding the segments together, but no additional investment in tools or equipment.

Method of Recovery — The quantities of the scrap accumulations largely govern the disposition. We have 20 service shops scattered throughout the country and their recoveries are relatively small. These, therefore, are sold to local metal dealers, on a competitive bid basis, who in most cases call for the material — we do the loading.

In our manufacturing plants, on the other hand, the amounts justify carload shipments and here we have well-organized salvage departments where the bulk of the materials are classified and prepared for direct use by the consumers.

Prompt Disposal — Yesterday's production of scrap is processed today. To save time, all-important as we all know, salvage methods have been stepped up so that most materials are classified, processed, and readied for shipment within 24 hr. of collection. This results in the most economical handling, saves space and storage equipment, eliminates many of the hazards of contamination, and, above all, returns the vital materials to war production quickly.

Re-Used Salvaged Materials — Approximately 20% of our recoveries are re-used as raw materials in our operations. Steel scrap is specially prepared for charging in our electric furnaces for making steel castings. Cast iron scrap is broken into suitable size for cupola charging to make cast iron castings. Copper scrap is wound into small bundles for crucible use in our alloy foundries. Several of our salvage departments have furnaces for reclaiming lead, babbitt, and solders for return to the operations where originally used.

Toll Agreements covered about 8% of our scrap in 1940. This means it was shipped on consignment to refineries, brass mills, and smelters for conversion into usable forms which were returned to us. Recent Government regulations have reduced considerably the possibilities of operating on this basis.

Disposal on Competitive Bids gives consumers, brokers, and dealers an equal opportunity. In this connection, I want to stress the point that the brokers and dealers perform a legitimate and important function in the scrap business and should be given every consideration. Most of our ferrous scrap is disposed of through them.

Selling on Analysis — Several years ago one of our officials asked me how I was disposing of a certain grade of scrap. I said, "On my wits." He replied, "No wonder we are realizing about half of what it is worth."

Today copper and copper-base alloys, lead, babbitt and solder, aluminum, silver, and alloy steels are consigned to the smelters and mills where the lots are sampled and assayed, and settlement is based on these assays. As a general rule, we hire public assayers to represent us.

Cooperation With Government Agencies — The war has brought home to everyone the importance of salvaging materials and the Government early recognized the vital need of recovered metals and placed them at the top of the list for control. The scrap business, due to its nature, is very complicated and in my opinion the government agencies have done a good job in regulating it. They cause us, as producers of scrap, some inconvenience, as we expend a great many man-hours making out reports on inventories, generations, usage, and disposition of recoveries. We lose a lot of sleep keeping up with the amendments to price schedules and we are not allowed to take care of some of our good customers, since many allocations designate the delivery.

However, the net result of all the red tape is that we know more about the scrap business than we did a year ago. We segregate the materials better. We turn them over faster. And the materials are going where they will do Uncle Sam the most good. These benefits will last long after the war is over.

There is only one issue today and that is to win the war. Make your decisions on the disposal of recoveries on the basis of how it will best win the war and you can't go wrong.

Bits and Pieces

(Metallurgicus' Own Page)

"Under-Hardening" of Steel

CONTROL OF HARDENABILITY of steel by deliberately hardening from temperatures too low to give complete carbide solution is "old stuff" in some applications, but has other uses not always thought of. (Toolsteels are usually "under-hardened" in the sense that some carbides are left undissolved.) For example:

Hyper-eutectoid carbon steels hardened from the usual temperatures are shallower hardening than eutectoid steels.

Carbon-vanadium steels are shallower hardening at the same hardening temperature than plain carbon steels.

High speed steel must not be heated long enough or high enough to put anything like all the alloy carbides in solution or the steel will remain austenitic on quenching.

And so on.

In such cases the undissolved carbides serve several functions. Carbon and alloying elements are kept out of solution, ineffective for hardening; carbide particles act as grain growth inhibitors (or as nuclei) and excessive grain growth won't occur while they remain; the free carbide particles also are good wear resisters.

The application of this principle to common alloy steels is less frequent but has many possibilities.

Putting or keeping some of the alloy carbides deliberately out of solution when hardening a carburized case on a highly alloyed steel is an effective way of reducing the tendency to retain austenite — see the Metals Handbook, page 1048.

Constancy of hardenability is highly desirable for uniformity of results. One aid, for chromium steels, is by deliberately under-hardening those of higher hardenability while fully hardening those on the low side. As shown by Grossmann's curves (reproduced on page 403, March *Metal Progress*) differences of 30% in hardenability may occur in a 1% chromium steel, depending on the amount of chromium carbides in solution, and therefore the hardenability of heats of various chemistries may be held more nearly constant by manipulating the time-temperature cycle for hardening.

Finally, by deliberate under-hardening, a high alloy steel may be kept from fully responding to heat treatment, and thus be used for a job where a lower grade steel is preferable, but not available. But this is extravagant and should only be used in emergencies.

METALLURGICUS

Decarburized Zones

IN THE November issue of *Metal Progress*, METALLURGICUS questioned the meaning of the terms "decarburization", "totally decarburized", or "total decarb".

In the ordinary sense, the term "decarburization" applies to the loss in carbon content of the surface layers of metal when a piece of steel or cast iron is heated in an oxidizing atmosphere. Under certain conditions of temperature and pressure it has been found that hydrogen or atmospheres high in hydrogen will also decarburize by combining with the carbon to form methane.

The terms "totally decarburized" or "total decarb" are somewhat ambiguous if they stand alone, since they seldom mean that the piece referred to has been completely robbed of carbon all the way through, although this may sometimes be true of thin sections. Rather, when we speak of "total decarb" we imply that the surface layer of a piece of steel has

lost its carbon to such an extent that a measurable zone of nearly free ferrite (containing say less than 0.10% carbon) is visible microscopically.

In either a "totally" or "partially" decarburized part, a carbon gradient exists from the surface inward, analogous to a carburized part where the carbon gradient steepens from the core outward. The writer in several studies on decarburization has adopted an arbitrary system of nomenclature for the various surface zones in a decarburized specimen, examples of which are given:

1. If a specimen is not completely decarburized at the surface, it is reported as being "partially decarburized to a depth of (say) 0.005 in.". The measured end point of the decarburized zone is taken as the location at which a change in the appearance of the unaffected core microstructure is just apparent. Sometimes it is very difficult to estimate this point, especially in a quenched and tempered piece, in which case the depth of decarburization is expressed as a range, say 0.004 to 0.006 in.

2. If a specimen shows complete or "total" decarburization at the surface (that is, nearly pure ferrite) the depth of decarburization is reported as follows:

Depth of completely decarburized zone	0.002 in.
Depth of partially decarburized zone	0.004
Total depth of decarburization	0.006 in.

In the latter instance the boundary of the completely decarburized zone is the point at which pearlite or carbides are just visible when a microscopic traverse is made from the outside surface inward on the specimen. Again, the end point of the zone of partial decarburization is estimated as in the first example. (Frank J. Altmann, Research Metallurgist, A. O. Smith Corp.)

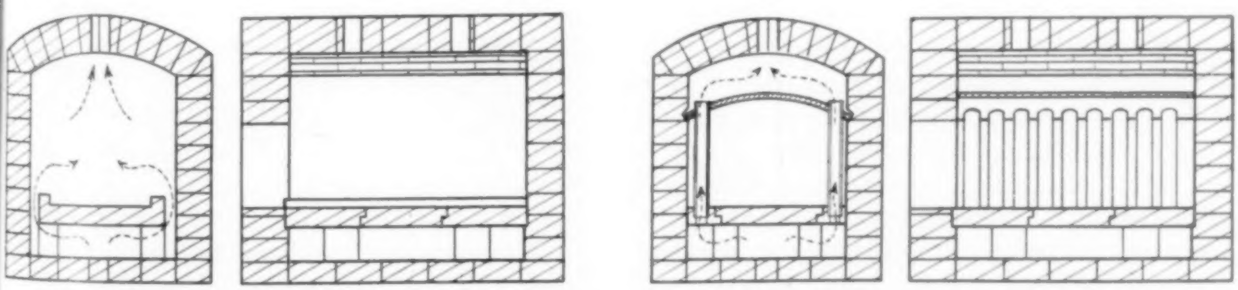
Converting Semi-Muffle Furnace to full muffle type

The most common heating furnace is the semi-muffle type, wherein the flame and the products of combustion come in direct contact with the work. If the air-gas ratio is so regulated to give the maximum heat per fuel input, the atmosphere within the working chamber is highly oxidizing. Where an "on-and-off" type of automatic control is used, two types of atmosphere are obtained. In either case there is undue scaling and decarburization of the work.

In an attempt to minimize these effects without the expense of making a complete change-over to an electric or controlled atmosphere furnace, the design of the semi-muffle can be altered to the extent of providing an enclosed path for the flame and flue gas from combustion chamber to vent, thus providing the working chamber with a "dead-air" type of atmosphere. This will scale and decarburize steels to a relatively slight extent, and the advantages gained far overshadow the cost of redesigning and rebuilding the furnace.

The change-over can be done without dismantling the furnace, assuming it is a relatively small one. First a false arch is installed, the arch usually being made in half sections of fireclay tile. The open spaces at the sides of the hearth, formerly used to vent the gases from the combustion chamber into the working chamber, are sealed with fireclay tube supports having round openings into which tubes are to be fitted. Tubes of fireclay (or preferably chrome refractory) are then fitted into holes in the false arch and the corresponding holes in the tube supports.

With this remodeled furnace the flame and products of combustion pass through the



Transverse and Longitudinal Cross Sections of Semi-Muffle Furnace for Tool Treatment (Left) and Similar Views After Conversion to Full Tubular Type

holes in the hearth, up through the tubes which become "radiant tubes", into the space between the furnace arch and the false arch, and then through the vent hole in the arch, all as shown in the accompanying sketches.

Heating is then solely by radiation and conduction, in exactly the same manner as obtained with an electric resistance furnace. Five years' experience with this type of furnace has indicated satisfactory operation with a low maintenance cost. Five such conversions are in continuous use. (R. F. Schaffer, Assistant Metallurgist, Gardner-Denver Co.)

Steel Shot
to protect edges of mount

In the mounting of specimens for microscopic examination of surface cracks, scale, cases, and surface structure, where it is necessary to round the edges as little as possible in the polishing operation, I find very helpful the trick I learned at the Allison Engineering Co. of using steel shot evenly spread over the surface around the specimen and embedded in the Bakelite or lucite mounting material.

The steel shot has polishing qualities similar to most metals, and thus prevents rounding the edges and gives about the same effect as polishing in a metal clamp. Also since the more you polish the greater the apparent diameter of the shot, that gives a means of polishing evenly the surface of the mount. (Harold W. Wyatt, Teaching Assistant, Massachusetts Institute of Technology.)

Rapid Identification Tests for manganese and sulphur in steel

Manganese and sulphur cannot be estimated with great accuracy by spark testing, especially when other elements in the steel are also present in unknown amounts. However, the following identification tests have been very useful to our inspector to supplement his sparking wheels. They work; "Sparkie" loves them!

Manganese — Grind a small concave spot on a horizontal surface. With a medicine dropper, add two drops of nitric acid solution (60 ml. water, 40 ml. HNO_3). Immediately after violent reaction has ceased, remove the acid drop from the steel with the medicine dropper and transfer it to a ½ x 4-in. test tube. Add two full droppers (about 2.5 ml.) of the nitric acid solution, then about 50 mg. of powdered sodium bismuthate ($NaBiO_3$), measured by a small scoop. Shake for about 10 sec., then let settle for about 5 min. The color of the supernatant solution varies from pale pink for steels containing under 0.20% manganese to deep purple for steels over 1.5%. To obtain a closer estimate, the solution may be compared with standards prepared at the same time and in the same way from a pair of steels of known manganese contents, selected from a set of reference bars. Alloying elements do not interfere, except by varying the rate of solution of the steel and hence the weight of the "sample". Volumes and conditions may be varied somewhat to fit individual circumstances. The timing of the reaction of the acid drop with the steel and the volume of acid must be maintained as uniform as possible from test to test for good results.

Sulphur — The standard metallographic sulphur print is a simple test which enables steels with normal residual sulphurs to be separated rapidly from resulphurized steels such as screwstock. The method is well known. This is the way we do it in the shop: Place a drop of 5% H_2SO_4 on the sensitized surface of a ½-in. square of photographic paper, and press it against a freshly ground surface. Sulphide inclusions cause a dark brown stain or print of silver sulphide to appear; the higher the sulphur content, the greater the density of the print. The print will develop within 15 or 20 sec. if the steel is warm, as from moderately heavy grinding, but may require a minute or more in contact if the surface is cold. Heavy rolled products should be tested midway between surface and center on the cut end to avoid the possible effect of segregation.

Equipment and reagents for these tests may be combined in a compact field kit with those for chromium and nickel (see *Metal Progress*, December 1942), and greatly increase the versatility and accuracy of a spark tester in sorting scrap or checking the analysis of bars, castings, or fabricated parts. (W. O. Philbrook, Research Chemist, Wisconsin Steel Works, International Harvester Co.)

Some Books

Worth Owning

For the Non-Expert

ELEMENTARY METALLURGY, by W. T. Frier. 206 pages, 5½x8 in., 109 illustrations. Published by McGraw-Hill Book Co., New York. Price $1.75.

Guys like Herb French and Kent Van Horn and Gordon Williams and a good many other metallurgical experts won't read this book, and if they do, they won't get much out of it. But, brother, if you are an amateur in this metal experting business, you'll want to read what W. T. Frier has put into "Elementary Metallurgy". And if you read it, you will understand it. You'll like that.

Mr. Frier starts at the beginning, describing the various steel making methods and practices and then takes you on an easy jaunt through the methods of forming metals, a few constitution diagrams, some notes on heat treatment, grain structure and the testing of metals.

He presents a lot of charts and pictures and because he has taught the subject for a good many years he gives you a peep into all the basic facts of metallurgical life. And because he is Foundry Control Chemist at the Erie Works of the General Electric Company, you get the idea that he knows what he is talking about.

Take the constitution diagrams, for example. They have seemed pretty technical and theoretical and annoying. But Mr. Frier shows how important these diagrams are in performing such practical jobs as heat treatment. Non-ferrous alloys are not neglected either. Facts about all of the important metals are there.

The book is fairly well indexed for reference, and all in all, the metallurgical beginner will find it well worth the buck seventy-five price. Elementary, my dear Watson!

AMATEUR METALLURGIST, Third Class

An Old Master

THE PIROTECHNIA OF VANNOCCIO BIRINGUCCIO (1540), translated from the Italian by Cyril Stanley Smith and Martha Teach Gnudi. Published by the American Institute of Mining & Metallurgical Engineers, New York City, 1942. 476 pages, 10½x7½ in., 100 line engravings. Price $5.

Those there are whose aesthetic nature enables them to recognize a work of art by the look and feel of the thing. Others there are who have tried to make such a thing, and measure the excellence of another's perfect production by the imperfections of his own.

This reviewer is of the second class. Having once collaborated with an Italian in attempting to convert a foreign text into the American metallurgical idiom, and on other occasions labored with printers in the production of printed works, he can appreciate the mountainous difficulties cleanly overcome in this beautiful book, and applaud the fortunate conjunction of so many stars — Dr. Smith the expert in metallurgy, Dr. Gnudi the expert in Italian literature, Carl Rollins the expert printer at Yale University Press, and Harvey Mudd and the other excellent trustees of the Seeley W. Mudd Memorial Fund (the financial angels who made possible this $15 book for $5).

Biringuccio was a practical metallurgist who worked during the first half of the 16th century. He believed what experiment and practice had taught him, and had small patience with the vaporings of the alchemists. He wrote down in his own language what he knew. He was a contemporary of Agricola, the mining engineer, who wrote what he knew and what he had heard — in Latin, thus getting a head start in intellectual circles over the Italian who wrote in words of the common man.

Herbert and Lou Hoover resurrected Agricola for the English-speaking world in a magnificent volume published 30 years ago (now a collector's item). Smith, Gnudi, Rollins and Mudd have now done the same thing for Biringuccio. All ye metallurgists, hurry and buy this item, for only 1000 copies were printed. It's an amazing bargain.

E. E. THUM

One of Many About Welding

In the past few years more and more effort has been given to achieve Utopia in a textbook dealing with welding — for the engineer, supervisor, foreman, as well as the operator, present or future. With this in mind, W. J. Chaffee has

written "Practical Arc Welding", which offers many new features but still lacks the scope required of such a book. It seems to be a combination of several booklets published previously by the Hobart Co. of Troy, Ohio, and also contains new information concerning arc welding which the layman, as well as the engineer, can easily understand. The excellent illustrations and the simplicity in explanations are additional points in its favor.

Although the book does not elaborate any branch of the subject, it is divided into several sections which make the thoughts clear to the reader. More stress might have been placed on safety during the training period and safe practices during operation. A better understanding of A.C. in comparison with D.C. equipment would be welcome, and where, when, and how to use these types of equipment.

The charts will certainly clear up much confusion. As a reference book it should be in every library, and near the engineer for a guide when tackling unknown jobs or checking himself on something unusual.

As yet the book for developing and training of welding engineers has not been written. This will some day be done. Universities that are teaching this course use several textbooks in order to include metallurgy, welding procedures and techniques, welding design and welding stresses, as well as textbooks giving the practical side of the art and industry. However, this book is so well written it may well serve as a guide for the author of this future ideal text. It costs $2.

JOSEPH V. KIELB

Metals for Aircraft

PROCESS PRACTICES IN AIRCRAFT INDUSTRY, by Frank D. Klein, Jr. (Senior Metallurgist, Materials Control Branch, U.S. Army Air Forces.) 266 pages, 46 illustrations, 69 tables, 6x9, blue cloth. Published by McGraw-Hill Book Co., New York. $2.75.

This book should prove a valuable reference for firms just entering into aircraft work. Especially the coverage of procurement methods, identification of materials and the index of specifications will be helpful to production and purchasing men not acquainted with AN standards and the processes of aircraft construction.

It cannot be considered a particularly valuable book for the student because of the brevity with which some very important subjects are dismissed as compared with the very detailed coverage of others. For example, the heat treatment of steel is given approximately five pages exclusive of data, while qualification tests for welders and welding occupy approximately 25. I would judge also that Mr. Klein uses too many technical terms, as do most authors, without explanation. Experience shows that most students are confused by this habit of the technical men, and it frequently induces a loss of interest in the subject matter.

Despite the above criticism, the book should be of value to new contractors and sub-contractors in the industry.

C. G. STEPHENS

AIRCRAFT TUBING DATA, by Summerill Tubing Co. of Bridgeport, Pa., is unusual in at least one respect: The descriptive matter contains complete discussions — like a series of technical articles — about the manufacture of tubing, its bending, welding, inspection and corrosion protection, all by experts in the aircraft industry. As a handbook for designers it contains indispensable tables showing sizes, weights, moments of inertia, and long column loadings permissible for hundreds of sizes in rounds, ovals, streamlines and square tubing. Page size is 8½x11 in., looseleaf in a ring binder. $2.00.

Some Genealogy

IRON MEN AND THEIR DOGS, by Ferdinand C. Latrobe. Published by Koppers Co., Bartlett-Hayward Division, Baltimore, 1941. 225 pages, 6½x9½, tan cloth. $4.50.

"Iron Men and Their Dogs" is a biography of the Bartlett-Hayward Division of the Koppers Co. The word "biography" was chosen because Mr. Latrobe gives the Division a personality. The iron men in the title refer to the guiding hands of Bartlett-Hayward from the founders, Hayward and Friend, stovemakers, of the ancestral establishment 102 years prior to the date of publication of the book. The dogs refer to cast iron replicas of two Newfoundland dogs, Canton and Sailor, ancestors of the Chesapeake Bay dog which stands guard at the entrance to the office. This emblem was chosen because Messrs. Hayward and Bartlett were persistent devotees of Chesapeake Bay's most notable sport, the pursuit of "that royal bird, the canvasback", and lovers of the Chesapeake Bay dogs, the retrievers.

In its 102 years of existence Bartlett-Hayward has manufactured a large variety of metal products. Starting with stoves, it soon branched into hot water and hot air heating systems and architectural cast iron. From 1863 to 1867 locomotives

were also manufactured. Later the firm became interested in the illuminating industry and installed and manufactured equipment for gas plants, which continued up to the present (at least until before the present war). From experience gained in the gas industry, Bartlett-Hayward was able to design and manufacture other plants including beet sugar refineries and toluol recovery plants. During the last war, shrapnel and shells were made. Since then has been developed the waterless gas holder. During the recent depression the firm made cast iron parts for government dams, modernized the brass foundry, and developed a high ductility, high strength bronze. The present war effort sees the making of gun carriages, variable pitch airplane propellers, and ship propellers.

Several chapters are devoted to hunting in Chesapeake Bay. Much of the book describes products manufactured by the Division; this is monotonous at times, but the description and pictures of the architectural iron are very interesting.

Morris E. Fine

Elements of Steel Making

Ferrous Production Metallurgy, by John L. Bray (Head, School of Chemical and Metallurgical Engineering, Purdue University). Published by John Wiley & Sons, Inc., New York, 1942. 457 pages, 6¼x9¼ in., cloth binding. Price $4.

Few books have appeared on this subject in recent years and any new contribution deserves serious consideration. So much attention has been paid to physical and theoretical metallurgy in the universities and technical schools that there is an unfortunate consequence: Too few graduates are properly grounded in the production phases to satisfy the needs of the iron and steel industry.

Professor Bray's work is a step in the right direction. According to the preface it is designed for a one-semester course of college work. This confines the contents largely to descriptive material, although some attention is paid to the physical chemistry of the processes. A fair balance is achieved in the amount of space devoted to the different processes according to their importance, greatest attention naturally being given to the blast furnace and the basic openhearth. Minor processes are not entirely neglected, however.

The author avoids illustrations almost completely. The reason given is that lantern slides are more effective in classroom presentation. However this makes the book less valuable outside the classroom, even though it serves to keep the cost down. This is somewhat offset by extensive use of line drawings.

The book is quite well up to date on new developments and is written in a simple and readable style. A minor annoyance is reference to tables and figures elsewhere without page reference, calling for needless thumbing through the book.

This is an excellent, moderately priced book for those who may have occasion to look up iron and steel making processes and who wish to avoid weeding through a mass of detail.

A. J. Smith

Modern Copper Smelting

Metallurgy of Copper, by Joseph Newton (Assistant Professor of Metallurgy, University of Idaho) and Curtis L. Wilson (Dean, Missouri School of Mines and Metallurgy). 518 pages, 6x9. John Wiley & Sons, N. Y. $6.

While evidently a teaching text, this book is also an expert's compendium of the most recent technical literature, containing adequate notes on such up-to-date items as molybdenum as a by-product of the porphyry copper mines, the methods for refining and casting oxygen-free, high conductivity copper, and for electroforming thin copper sheet.

The general plan of each chapter is to state first the scientific principles of the metallurgical operation under consideration and then to cite definite practice at this and that important producing plant. Extended descriptions of mines, mills and smelters in Canada, Africa and South America emphasize the fact that the era is passing when the United States was the world's storehouse for copper. An excellent and fascinating chapter tells of the development of reverberatory smelting and the engineering or commercial reason for each change in furnace or practice. It is quite the high spot of the book, alone enough to make it notable; one regrets that similar exhaustive treatments of other processes are not given, but perhaps this would be beyond the knowledge of any two authors. A golden opportunity exists for a similar consideration of the problem of smelter smoke — that is, the SO_2 that is thrown out into the atmosphere. Strangely enough this problem (which has cost the smelting industry millions upon millions of dollars to solve adequately) is hardly mentioned in an otherwise satisfactory chapter on the by-products going up the flue, such as heat and fume, and the production of sulphuric acid.

Of course, the 50 pages devoted to properties and uses of copper and its alloys can be nothing more than a sketchy introduction to a closely related subject nearly always ignored in texts of this sort. Another 50 pages devoted to production and trends in the smelting industry contain, strangely enough, statistics dating no later than 1937 or 1938.

E. E. Thum

Blasting the Surface

Impact Cleaning, by William A. Rosenberg (Consulting Engineer). Published by Penton Publishing Co., Cleveland, Ohio. 6x9 in., red cloth, 466 pages. Price $7.00.

The author of this book has been forced to coin and use a new term as a title in order to adequately describe the processes he has included. If he had used the old fashioned subtitle, such as found in the Horatio Alger books, more of his potential readers would have recognized the book as an aid to their problems. Sand blasting, shot blasting, and the newer methods of impact cleaning, using centrifugal force as motive power for the abrasive, are all embraced under the general term "impact cleaning". Each process is discussed from the theoretical and practical angle; several chapters are devoted to each of the more important applications.

The book is divided into three parts. Part I covers nozzle blast cleaning and equipment; Part II airless or mechanical cleaning; and Part III contains the equally important subjects of ventilation, dust removal and dust control.

It is gratifying to have someone come out at last and recognize the maintenance problems that are always present with this type of equipment. If all users and prospective users could be forced to study the author's comments on up-keep, such as given in Chapter 30, many time-consuming and heated arguments between the operating and maintenance departments could be avoided! Manufacturers of this equipment could also profit from the author's remarks regarding clearances between moving parts.

One discordant note is the inclusion of page after page of mathematical formulae. In the introduction the author states that this book is written for the buyer and user of this equipment, and only the very few hardy souls that design and build their own equipment would have any use for this theory. To most all others it only acts as a mental hazard — even a bunker which will effectually stop them. The operating man opens the book to a page covered with unfamiliar symbols and closes it before he reads enough of the text to realize that he can get all the information he requires by simply skipping the mathematics. Put them in an appendix!

J. B. Caine

A Compendium of Tests

Hardness and Hardness Measurements, by Samuel R. Williams. Published by American Society for Metals, Cleveland. 558 pages, 330 illustrations, 21 tables, 6x9, red cloth. $7.50.

This book is an assemblage of much of the available knowledge concerning hardness, including investigations made by the author. Although written by a physicist, a knowledge of modern physics is not necessary to its understanding. It is clearly brought out that hardness, as measured by the methods familiar to the metallurgist, is not a simple property but a combination of several properties.

The first two chapters deal with fundamental definitions and the relation of crystal and atomic structure to hardness. These are disappointing. None of the recent material correlating the hardness with crystal structure is mentioned. Unmentioned are the different types of chemical bonds, according to modern theory; this is certainly related to hardness. The author raises the question of the cause of the diamond's hardness. According to him when questions like this are answered much of the mystery connected with hardness will be removed, but the hardness of diamond can be partially explained by the strong covalent bond between the atoms. Much space is devoted to the fundamental type of particle present in the atom nucleus, and yet the outer electrons are pictured according to the old Lewis-Langmuir shell theory.

A very good description of Bierbaum's Microcharacter is given and one chapter is devoted to each of the following: Brinell, Rockwell, and pyramidal indenter methods of hardness testing.

The latter part of the book deals with the relation of elastic, magnetic, and electrical properties to hardness. The physical processes which occur at the point where a hardness test is made are discussed, as well as the strains involved and the relation of creep to hardness testing.

As a compilation of different methods of measuring hardness this book serves a purpose. The descriptions of the different testers are clear, and the concept involved is discussed fully, although precautions to be used in operating the testers are not listed. This book is of interest to others besides metallurgists, since non-metallics are also treated.

Morris E. Fine

Boundary Lubrication*

THE SUBJECT of lubrication is usually divided into full-fluid or hydro-dynamic lubrication, and boundary lubrication. Full-fluid lubrication depends almost entirely on the viscosity of the lubricant, while boundary lubrication is affected by the geometry and the chemistry of the bearing surface.

The Bearing Surface — Grain boundaries occurring on the metal surface have different chemical and physical properties from the interior of the grains and thus cause a variation of chemical activity of the surface from point to point. This variation may affect the "affinity" of the lubricant for the surface. Furthermore, the different crystal faces of a grain vary physically and, in polycrystalline metals having random crystal orientation, each grain will expose a different face to the surface. Certain mechanical working and recrystallization treatments may produce a preferential orientation of one or two faces in the surface. If, in addition, we have more than one phase, the local variation of surface properties will be even greater. Worse yet is the presence of foreign materials as inclusions.

In addition, one must consider the surface roughness. The coarser finishing operations produce surfaces with the greatest roughness, that is, the height of the peaks above the valleys is the largest. These surfaces also have a steeper average slope. This means a smaller true area of contact and hence severer conditions for the boundary lubricant. For this reason the "root-mean-square average slope" is as important as the "root-mean-square roughness" itself in lubrication problems and should certainly be specified. Friction increases with roughness up to about 20 micro-inches, after which it is essentially constant.

Directional quality of surface profile also can markedly affect bearing performance. Also, the size and quantity of "fuzz" left on the finished surface affects the lubrication.

The Lubricant — A good lubricant should have a high energy of adhesion, the structure of its molecules should be such that it can form a close-packed film of relatively large thickness.

(Continued on page 584)

*From "The Role of Surface Chemistry and Profile in Boundary Lubrication", by J. T. Burwell, S.A.E. *Journal (Transactions)*, Vol. 50, No. 10, October 1942, p. 450.

Lubrication

(Continued from page 582)

and if only a portion of its molecules be surface active, enough of these should be present to repair the surface film quickly enough to prevent prolonged metal-to-metal contact.

Energy of Adhesion — The "wettability" of oil for the bearing surface is a function of both the surface and the oil, but appears to depend much more on the latter. This function has the dimensions of energy per unit area, corresponding to the work necessary to pull a unit area of oil away from the metal.

The energy of adhesion may be measured by the heat of wetting or by the contact angle, preferably the latter. When a quantity of liquid is placed on a surface, it spreads until it reaches an equilibrium position when its shape is governed by its surface tension, its specific gravity, and by the angle at which its surface meets the solid. There is only one such equilibrium position. Now, if the surface instead of being smooth has a profile, the liquid may come to rest in a given position regardless of where its position on the corresponding smooth surface might have been. There might be a lot of the liquid piled up behind the surface and gravity would tend to make it spread, but it will not advance down the slope because then the contact angle would be less than the equilibrium one. On the other hand, it might have been initially spread too thin so that the surface tension would want to pull it back, but it will not recede because then the contact angle would have to be less than equilibrium. Thus, a rough surface contributes to the hysteresis or spread between the advancing and receding angles of the liquid over the surface. If once spread, a lubricant will stay spread further than on a smooth surface but, if initially added in one spot, it will not spread as far as it would otherwise. Rough surfaces can only be detrimental for oils that have small contact angles, but for an oil with a large contact angle, the rough surface should help.

Molecular Structure of the Lubricant — High energy of adhesion is not the only quality necessary for a good boundary lubricant. The molecule must in addition have the correct shape. A long straight chain seems to be best with the active or adhesive radical on one end. A lateral close packing of the chains and an equally close packing of the active radicals mean a maximum adhesion per unit area of film. If the concentration of surface-active material in the lubricant is great enough, the molecules can diffuse to the surface and recoat it quickly.


TROUBLE SPOT

Influence of Cast Structure on Mechanical Properties*

EXPERIMENTAL work to relate crystal orientation with mechanical properties has so far been mostly concerned with the mode of deformation of a single crystal or of a few large crystals. Very little information is available dealing with the influence of both crystal size and orientation upon the mechanical properties of non-ferrous alloys in the cast condition, and the subject was therefore investigated.

By employing a special method of casting, a variety of crystal structures could be obtained in one ingot. The ingots were cast in the Durville tilting mold, the mold being arranged for unidirectional solidification.

The following copper alloys were examined: 15, 30, 40, and 47% zinc; 1, 5, 7, and 10% aluminum; 2, 6, 10, and 13% tin; 0.1 and 0.5% phosphorus. Pure zinc and magnesium, representative of metals crystallizing in the hexagonal rather than the cubic system, were also studied.

Test pieces of zinc-copper alloys composed of longitudinal columnar crystals showed the lowest ultimate strength but highest elongation. Transverse columnar crystals gave higher strengths but lower elongations, and equi-axed crystal samples showed the highest values for maximum stress but low to intermediate values for elongation, and the greater the number of crystals per unit area the greater was the maximum stress but the lower the ductility. Similarly, the greater the difference in size between the columnar crystals and the smaller equi-axed ones, the greater is the difference in the properties of the test bars containing them.

It is of interest that the only brass showing a negligible difference in properties between the columnar and equi-axed crystal types is the 60:40 alloy, and this is the only one examined which undergoes a transformation on cooling (in this instance to form a mixture of the alpha and beta phases).

Results obtained with the single-phase and two-phase aluminum-copper alloys confirm those obtained with the corresponding zinc-copper alloys and with the tin-copper alloys. Phosphorus-copper alloys are also strengthened as the crystal size is decreased, and the accompany-

(Continued on page 588)

*Abstracted from "The Influence of Crystal Size and Orientation Upon the Mechanical Properties of Metals in the Cast Condition", by L. Northcott. *Journal* of the Institute of Metals, Vol. 68, 1942, page 189.

Cast Structure

(*Continued from page 586*)

ing slight loss in ductility is shown more by the reduction of area than by the elongation measurements. Tensile properties of the transverse columnar crystal samples are similar to the longitudinal crystal samples when the number of crystals is similar, and are only higher when the number of crystals is much greater.

Examination of Test Pieces — The influence of macrostructure on deformation is reflected by the appearance of the test piece during and after testing, the obstruction to deformation near the boundaries being well shown, especially in the equi-axed samples. Fractures were of the usual ductile type in the softer alloys, wedge-shaped in columnar crystal samples, and circular cup-and-cone in the samples wherein the metallic crystals were small and equi-axed.

Notched-Bar Impact Tests — In view of the influence of grain size upon the impact value of steels, it was anticipated that appreciable differences would also be found in the present non-ferrous alloys, but this was not true. While there was a wide range of values, when different compositions are compared, the impact values of samples cut from the same ingot were sensibly the same, irrespective of crystallinity.

Hexagonal Metals — It was thought worth while to include a few results of tests made on metals having the hexagonal lattice structure, because the mode of deformation of such materials, tested in single-crystal form, is known to be very different from the cubic metals. The zinc used was electrolytic metal of 99.99 + % purity and the magnesium metal analyzed 99.92% Mg.

The tensile properties of these hexagonal metals differ in two important respects from the face-centered or body-centered cubic metals and alloys. In the first place there is a considerable difference in the properties of the columnar-crystal aggregates when tested in the longitudinal and transverse directions, the longitudinal test pieces of zinc being as much as four times as strong as the latter. In the second place, the ultimate strengths of the equi-axed crystal test pieces are not greater than those of the columnar crystals taken as a whole, but are intermediate in value between the strengths of the columnar crystals tested longitudinally and tested transversely. This finding seems reasonable enough when the mode of deformation of these hexagonal metals is considered, for the grain boundary effect is outweighed by the directional properties of the crystal itself. (*Cont. on p. 590*)

Cast Structure

(Starts on page 586)

Three main conclusions are:

1. The tensile properties of crystal aggregates of single-phase copper-rich alloys are greater the smaller the crystal.

2. The tensile properties of two-phase alloys are less affected by crystal size.

3. In the coarse crystalline samples of zinc and magnesium examined, the mechanical properties are more affected by the orientation of the crystals than by their size.

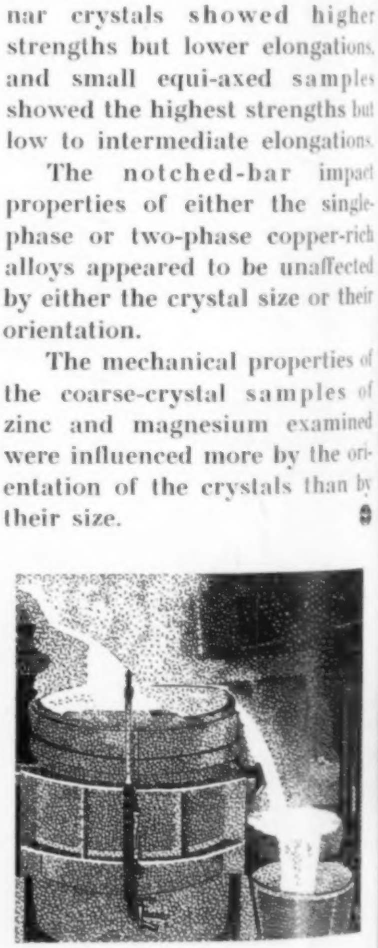
Since even the smallest crystals studied are very large relative to the spacing of the atoms, the difference in properties is evidently associated with the influence of the crystals on each other exerted at the boundaries, and is not related to the intrinsic properties of the crystals.

Whatever the true nature of the boundary, and irrespective of whether it is intrinsically stronger or weaker than the crystal itself, it exerts a beneficial influence upon the strength of the crystal aggregate and offers obstruction to flow. The small effect on mechanical properties of the size of the crystals of the cast structure in two-phase non-ferrous alloys is similar to that observed in steels.

Conclusions — While the tensile properties of crystal aggregates of single-phase copper-rich alloys were found to increase with decrease in crystal size, no straight-line relationship was found between maximum stress and either grain boundary area or crystal size Test pieces composed of columnar crystals disposed longitudinally showed lowest strengths but highest elongations; transverse columnar crystals showed higher strengths but lower elongations, and small equi-axed samples showed the highest strengths but low to intermediate elongations.

The notched-bar impact properties of either the single-phase or two-phase copper-rich alloys appeared to be unaffected by either the crystal size or their orientation.

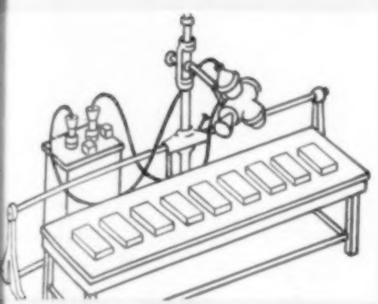
The mechanical properties of the coarse-crystal samples of zinc and magnesium examined were influenced more by the orientation of the crystals than by their size.



Flexibility TO YOUR X-RAY DEPARTMENT

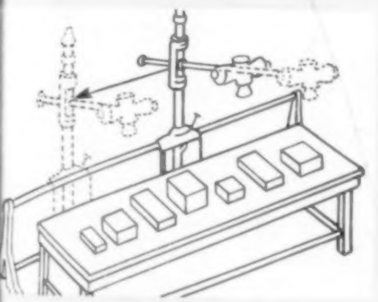
GET BOTH WITH THIS WESTINGHOUSE X-RAY UNIT

The Westinghouse Rail-Mounted X-ray Unit permits unusual speed and flexibility in the x-ray department. Rated at 140 kv capacity, it is especially suited for the inspection of light alloy parts and moderate thicknesses of heavier metals. Its control is largely automatic . . . easy to adjust for proper exposure.



SPEED TO INSPECT MORE PARTS FASTER.

This unit is designed to save time. Parts can be placed on a large worktable and radiographs made, one after the other, simply by moving the unit to the next position. Parts of varying sizes and shapes can be x-rayed quickly, since the tube-head adjusts easily and the controls are simple. When parts are identical, the radiographic work is reduced to sliding the unit along the rails and making successive exposures.



FLEXIBILITY TO INSPECT MORE KINDS OF WORK.

This unit also has the flexibility demanded in today's production. Ideal for light alloy work, it quickly penetrates aluminum up to 7½" thick. In addition it will produce sharp, detailed radiographs through 1½" of steel; 1" of brass. The counterbalanced tube-head and tube-arm permit the beam to be raised, lowered and directed over a large area with speed and great accuracy. The entire unit occupies a minimum of floor space, a large part of which is available for positioning the work.

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Check the many features of this 140 kv unit. It will make a profitable investment for your plant, both now and after the war. Your nearest Westinghouse X-ray Office has full details. Or write Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., Dept. 7-N.

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Industrial X-ray

Calibration of Platinum Thermocoupl at Steel Melting Range*

QUICK-IMMERSION technique for measuring the temperature of molten steel is being usefully employed in steel making. In the preliminary experiments the absolute accuracy of calibration of the thermocouples was not of importance, but now that the method appears to be well established, an accurate calibration is clearly desirable. Hitherto, platinum couples have not been used extensively above about 1550 (2825° F.) on account of the re tively rapid rate of deterioratio of the couple wires at su temperatures.

The method depends on fixed temperatures of the melti points of gold (1063° C.), pa ladium (1555° C.), and platinu (1773° C.). A short length of th melting point metal is join between the ends of the two wir of the thermocouple under ca bration (test couple) and place together with another coup (control couple), in an electr cally heated furnace, the tempe ature of which is slowly raise alternate readings of the e.m of the couples being taken on potentiometer. When the mel ing point of the metal is reache the e.m.f. of the control coup continues to rise, while that the test couple remains stead for a minute or two and the drops to zero on the breaking the circuit due to the fusion the metal forming the junctio The steady e.m.f. value immed ately before the rupture is tak to be the e.m.f. of the couple the melting point of the met No additional wire is needed the platinum experiment sin the melting point material form one arm of the thermocoupl The thermocouple wires we fused together at the junctio and the position of the coup was adjusted at the hottest po of the furnace; hence fusion com menced at the junction. Th platinum wire, after fusion the junction, was still held

(Continued on page 600)

*Abstracted from "The Calibr tion of the Pt vs. 13% Rd-Pt Th mocouple Over the Liquid St Temperature Range", advance co (Dec. 1942) of paper for Briti Iron & Steel Institute, by C. Barber.

Calibration

(*Continued from page 598*)

contact with the platinum-rhodium wire by surface tension of the bead, which moved up the alloy wire as the platinum arm melted back. The e.m.f. of the couple remained steady to within 2 or 3 microvolts while the platinum arm was melting back some 1.5 cm., leaving little doubt that the melting point given was that of the pure platinum.

A long tube furnace set vertical was specially constructed, with tube of recrystallized alumina wound with rhodium foil 6.3 mm. wide by 0.075 mm. thick. Various precautions were taken to avoid extraneous effects due to current leakage and electrolysis.

Eight couples made with pure platinum and 13% rhodium wire secured from two sources were tested. The average e.m.f.'s in millivolts at the standard temperatures were found to be:

Gold, 11,358 mv. at 1063° C. (1945° F.)

Palladium, 18.192 mv. at 1555° C. (2831° F.)

Platinum, 21.114 mv. at 1773° C. (3223° F.)

From these data and information from other laboratories concerning e.m.f. at temperatures around 1400° C. the following equation will give the relationship between Centigrade temperature t and electromotive force e in microvolts in the range from 1400 to 1773° C., accurate to within ±3° C. up to 1600° C., and ±5° C. beyond that temperature:

$$e = -7966 + 19.820t - 0.001928$$

From this relation the following tabulation has been figured, accurate to the above-mentioned limits. [Fahrenheit equivalents were computed by the Editor of *Metal Progress.*] Cold junctions are at 0° C. (32° F.). When two compensating leads are used, care should be taken to insure that the two junctions between the compensating leads and the thermocouple wires are at the same temperature, and that this temperature does not exceed 100° C. Otherwise, serious errors may be introduced.

Platinum Couple Calibration

Temperature	Millivolts	Temperature	Millivolts
1400° C.	16.00	2520° F.	15.74
1420	16.29	2560	16.06
1440	16.58	2600	16.39
1460	16.86	2640	16.71
1480	17.14	2680	17.02
1500	17.43	2720	17.33
1520	17.71	2760	17.65
1540	17.98	2800	17.96
1560	18.26	2840	18.26
1580	18.54	2880	18.57
1600	18.81	2920	18.87
1620	19.08	2960	19.18
1640	19.35	3000	19.48
1660	19.62	3040	19.77
1680	19.89	3080	20.06
1700	20.16	3120	20.36
1720	20.42	3160	20.65
1740	20.68	3200	20.94
1760	20.94	3240	21.23

New Products

New Size Furnace

With a view of improving quality and utility, the Sentry Co. of Foxboro, Mass., announces a new edition of its size No. 2 model "Y" electric high speed steel hardening furnace, containing many features shown desirable by several years of user experience. For the operator's

convenience, an asbestos loading shelf has been added at the front. Width and depth permits easy arrangement of several furnace loads. From the safety point of view, new metal guards prevent possibility of accidental contact with live power. Many details have been redesigned for added strength and durability. These improvements have been made at no increase in price, and "diamond blocks" used in Sentry furnaces have recently been substantially reduced in price.

Biggest Welder

Final adjustments are being made on the world's largest machine for spot welding aluminum and steel in the plant of the Sciaky Bros., Chicago. Towering nearly 9 ft. high, this 20-ton spot welder is fully adaptable to the welding of $\frac{3}{16}$" aluminum sheets and $\frac{1}{4}$" steel plates. This machine for the first time, it is said, puts direct current to use in the successful welding of steel. It uses 240 kilowatts of electrical energy, and has a maximum electrode pressure of 12,000 lb.

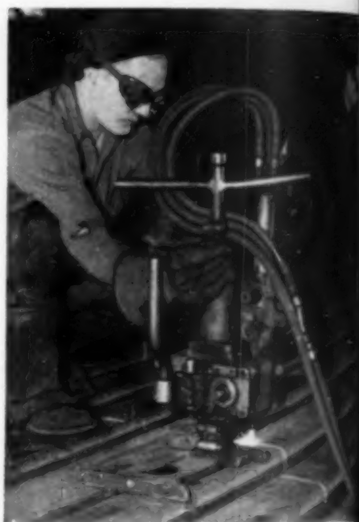
"Glotemp" Furnace

Harry W. Dietert Co. of Detroit announces a new "Glotemp" combustion furnace for making rapid carbon and sulphur determinations. Its outstanding feature is the short over-all length of the furnace. There is no sacrifice in efficiency since Globar heating elements are placed at right angles to the combustion tube, so that the electrical connections are to one side of the housing. Small combustion tubes speed the determinations considerably because a smaller volume of gas is handled. Heat is confined in this furnace to the section of the 21-in. tube where it is required for the rapid combustion of the sample. Another advantage is that both ends

of the combustion tube are fully exposed to insure efficient cooling so as to prevent oxidation of rubber connections.

Bar Cutting Simplified

Bar cutting machines of the portable type are being used in various mills to square the ends of rolled bars, to remove etch-test specimens, to cut bars to shipping length, and to divide bars into lengths required for individual forgings, according to Linde Air Products Co., New York City. This oxy-acetylene machine requires



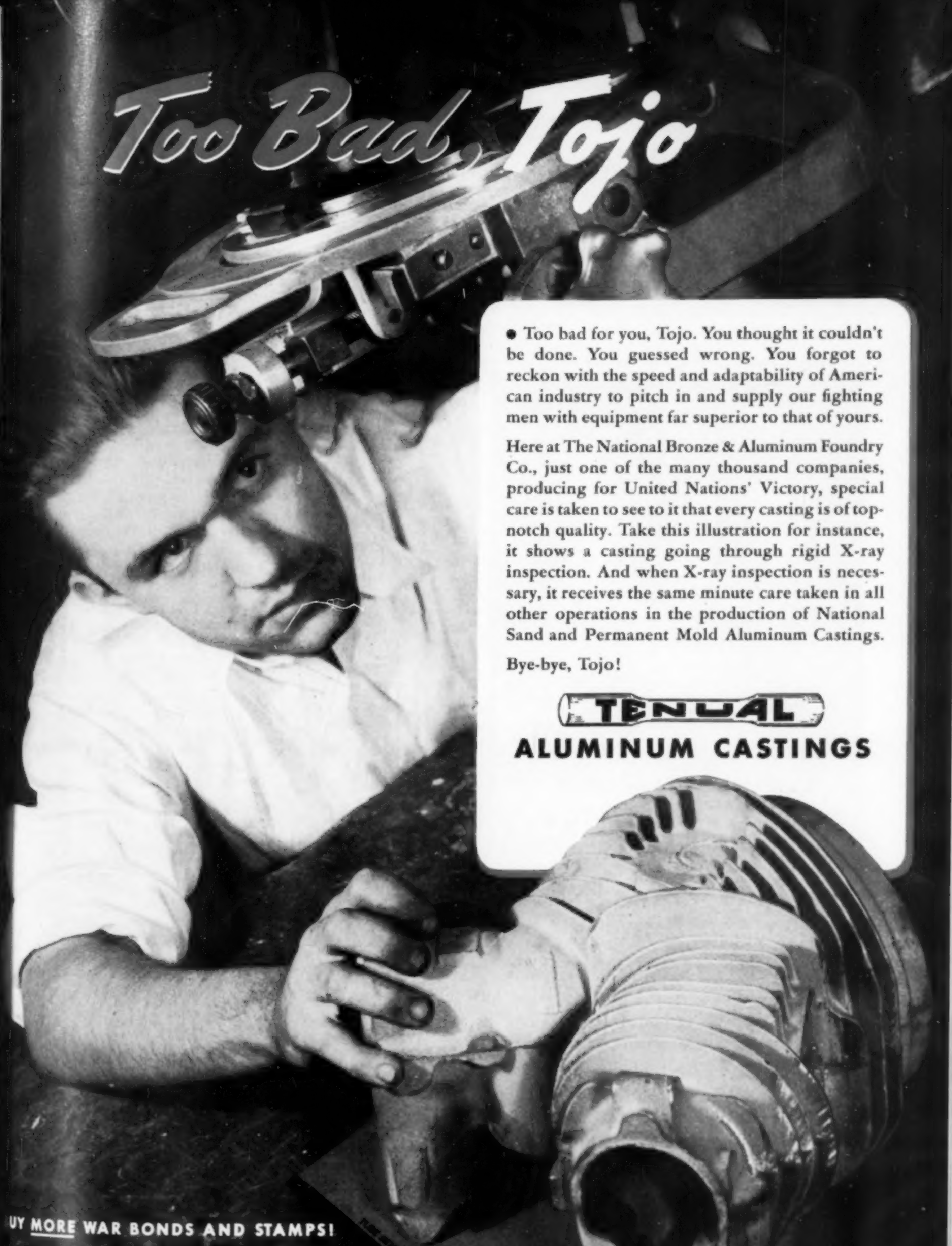
neither electric power nor track on which to operate; it is placed directly on the material to be cut whether it be round or square. The cutting blowpipe is automatically guided along the contour of the bar by a swinging mechanism, actuated by a self-contained hydraulic power unit.

X-Ray Film Cassette

Stele-Weld Rayspeed cassette, a development of the General Electric X-Ray Corp., Chicago, fits practically all makes and types of X-ray equipment, and is the strongest most rigid cassette yet designed.

Exclusive new spring-leaf hinges assure uniform screen-film contact by allowing screens to float naturally over entire film area, and protect screens by preventing pinching at the hinged end, and by eliminating sideplay in the back. The face won't buckle from expansion or pressure, as free space is left on all sides between face and frame. Face is quickly removed by unscrewing frame and removing

(*Continued on page 618*)


Too Bad, Tojo
UY MORE WAR BONDS AND STAMPS!

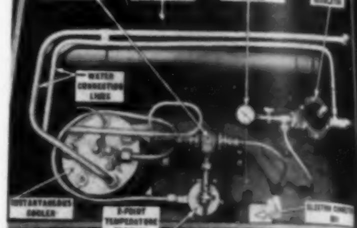
New Products

(*Continued from page 616*)

the front section. New button stops on back eliminate groping for locking springs by limiting their rotation. Handy steel lift-ring aids raising and lowering the back.

Refrigerating Unit

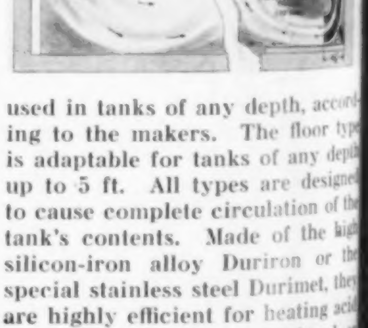
Increasing use of industrial X-ray machines for flaw detection and inspection centers means the production of exposed film on a greatly expanded basis. This requires extremely accurate limits on three major factors — immersion time, solution strength, and solution temperature. The third depends entirely upon conditions under which the equipment is used and may vary from day to day or hour to hour. Lack of uniformity in the solution temperature may nullify the first two factors and result in unsatisfactory prints. To eliminate this variable hazard, Temprite Products Corp. of 45 Piquette Ave., Detroit, has designed its model 555-PD refrigerating unit to circulate large quantities of water at con- trolled temperature (recommended as 65° F.) around the processing solution containers in the develop- ment tank. At the same time, a large volume of clean water at con- trolled temperature is always avail- able for washing the film, because all used water is drained off and



not recirculated. One unique fea- ture claimed for this unit is that the waste water is used in a heat interchanger to pre-cool the fresh water inlet coil, thus permitting the use of much smaller refrigeration equipment on high capacity instal- lations.

Steam Jets for Heating Solutions

Three new circulating steam jets have been announced by the Dur- iron Co. of Dayton, Ohio. In addi- tion to corrosion resistance, they have the advantage of fitting snugly to the inside walls of either square or circular tanks, with a maximum projection of 4½ in. Suspended and center discharge types may be



used in tanks of any depth, accord- ing to the makers. The floor type is adaptable for tanks of any depth up to 5 ft. All types are designed to cause complete circulation of the tank's contents. Made of the high silicon-iron alloy Duriron or the special stainless steel Durimet, they are highly efficient for heating acid solutions, dissolving powdered or lump chemicals, and for the diges- tion of ores and separation of sludge acids.

WHAT'S NEW

IN MANUFACTURERS' LITERATURE

METAL WORKING • FABRICATION

"Cylindrical Superfinishing." International Machine Tool Corp., Foster Div. Bulletin Hf-410.

Forging presses. Ajax Mfg. Co. Bulletin Ff-105.

Horizontal extrusion presses. Hydropress, Inc. Bulletin Ff-394.

36-page pictorial story of the Cecostamp. Chambersburg Engineering Co. Bulletin Ff-132.

Cutting Oils. Cities Service Oil Co. Bulletin Ec-113.

Cutting Oil Handbook. D. A. Stuart Oil Co. Bulletin Ke-118.

Presses for Powder Metallurgy. F. J. Stokes Machine Co. Bulletin Af-335.

Properties and uses of cutting oils. Gulf Oil Corp. Bulletin Ef-360.

Forty different ways to cut machining costs. Continental Machines, Inc. Bulletin Ef-170.

Mounted wheels, Handee and Hi-Power tools. Chicago Wheel & Mfg. Co. Bulletin Kf-230.

Savings in oils, tool bits, grinding wheels. Sparkler Mfg. Co. Bulletin Kf-433.

Convenient, pictorial chart shows abrasive cloth gadgets in a form that will guide users in the proper finishing operation. Behr-Manning Corp. Bulletin Nf-467.

"Hyper-milling", a radical innovation in face-milling of steel. Firth-Sterling Steel Co. Bulletin Lf-177.

Abrasive belt polishing machines. Divine Brothers Co. Bulletin Kf-434.

Cutting oils. Warren Refining & Chemical Co. Bulletin Kf-454.

Surface coated abrasive belts for producing faster finishes. Minnesota Mining & Mfg. Co. Bulletin Ag-470.

Illustrated literature on presses for powder metallurgy. Hydraulic Press Mfg. Co. Bulletin Cg-475.

Grinding and polishing with abrasive belts. Hammond Machinery Builders, Inc. Bulletin Cg-363.

High production presses. E. W. Bliss Co. Bulletin Cg-380.

Illustrated data information on cutting oils and their correct use in machining operations. National Refining Co. Bulletin Cg-479.

New handbook to aid in riveting operations on aircraft has been issued by the Cherry Rivet Company. Charts, diagrams, dimensional sketches and photos give a clear picture of airframe construction. Bulletin Dg-486.

Speed and economical production of small stampings with new Hi-Speed press described in leaflet by Di Machine Corp. Bulletin Dg-490.

New 52-page tool manual for operators of metal cutting machines has been issued by McKenna Metals Co. Bulletin Dg-238.

Information and data on new straightening press is offered by Anderson Bros. Mfg. Co. Bulletin Dg-491.

FERROUS METALS

Information on SuVeneer clad metal. Superior Steel Corp. Bulletin Cg-474.

Enduro stainless steels. Republic Steel Corp. Bulletin Hf-8a.

"100 Years of Peace and War" title of attractive brochure celebrating 100th birthday of Joseph T. Ryerson & Son, Inc. Bulletin Bg-106.

Hard Facing Alloys. Wall-Colmonoy Corp. Bulletin Kd-85.

Free Machining Steels. Monarch Steel Co. Bulletin Cd-255.

Tool Steels. Bethlehem Steel Co. Bulletin Ce-76.

Die Steels. Latrobe Electric Steel Co. Bulletin Ld-208.

Enameling iron sheets. Inland Steel Co. Bulletin Ld-295.

NAX high tensile low alloy steels. Great Lakes Steel Corp. Bulletin Kd-229.

Loose-leaf reference book on molybdenum steels. Climax Molybdenum Co. Bulletin Hb-4.

Four Coppco tool steels. Copperweld Steel Co. Bulletin Cf-311.

Nitralloy and the Nitriding Process. Nitralloy Corp. Bulletin Df-116.

Information for determining overall heat transfer rates. International Nickel Co. Bulletin Kf-45.

Aircraft steels, bearing steels. Rotary Electric Steel Co. Bulletin Kf-429.

Steels. Boker & Co. Bulletin Kf-450.

Cold drawn steels. Wyckoff Drawn Steel Co. Bulletin Kf-99.

Steel Data Sheets. Wheelock, Lovejoy & Co. Bulletin Ox-74.

Saving of stainless steel through use of Pluramelt. Allegheny Ludlum Steel Corp. Bulletin Df-92.

Molybdenum wrought steels. Molybdenum Corp. of America. Bulletin Nf-312.

Use Handy Coupon Below for Ordering Helpful Literature. Other Manufacturers' Literature Listed on Pages 622, 624, 626, 628, 630, 632 and 634.

Metal Progress 7301 Euclid Ave., Cleveland
Send me the literature I have indicated below.

Name .... **Title** ....

Company .... **Address** ....

(Students—please write direct to manufacturers.)
Check or circle the numbers referring to literature described on these 8 pages.

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WHAT AJAX SIGNIFIES
AJAX METAL COMPANY
AJAX NON-FERROUS INGOT METALS: The first program for scientific control of ingot metal production was set up in and by the Ajax Metal Company 45 years ago. The result continues to be a sense of sureness and faction in all the dealings of foundrymen with this pany. Philadelphia, Pa.
JAX ELECTRIC FURNACE CORP.
Division of Ajax Metal Co.
AJAX-WYATT INDUCTION MELTING FURNACES: Virtually all the brass mills in North America use these furnaces because they have the lowest metal losses in the field—less than 1%—with superior temperature control and unapproached economy of operation on high production schedules such as we have today. Philadelphia, Pa.
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Division of Ajax Metal Co.
HIGH-FREQUENCY MELTING AND HEATING: Development of high frequency melting and induction heating as early as 1916 represents a basic contribution of Ajax research to metallurgical art. Use of Ajax-Northrup units is the trend in melting high alloy tool steels, magnet steels; for centrifugal castings; and heating for hot-forming. Trenton, N. J.
AJAX ELECTRIC CO., INC.
Division of Ajax Metal Co.
AJAX-HULTGREN SALT BATH FURNACES: Over a thousand of these furnaces have been installed. For practically every heat-treating operation from 300° F. to 2400° F., the Ajax-Hultgren Electric Salt Bath Furnace has definitely proved its advantages and received the acclaim of leading metallurgists throughout the world. Philadelphia, Pa.
AJAX ENGINEERING CORP.
Division of Ajax Metal Co.
ALUMINUM MELTING FURNACES: Advantages inherent in the original Ajax-Wyatt low-frequency melting principle and design are found in the Ajax-Tama-Wyatt furnace, incorporating original and specific features for aluminum melting, permitting production of homogeneous alloys with diminished oxidization and no danger of overheating or underheating. Trenton, N. J.
SINCE 1880

WHAT'S NEW

IN MANUFACTURERS' LITERATURE

New process embodying both chemical and temperature controls for production of low carbon open hearth case carburizing steel is described in bulletin by W. J. Holliday & Co. Bulletin Bg-293.

Shop notes on the machining of stainless steels. Rustless Iron & Steel Corp. Bulletin Nf-169.

NON-FERROUS METALS

Silver alloy brazing. Handy & Harman. Bulletin Hf-126.

Bronze. Frontier Bronze Corp. Bulletin Kf-455.

6th edition of Revere Weights and Data Handbook. Revere Copper and Brass, Inc. Bulletin Bg-239.

Copper Alloys. American Brass C Bulletin Kd-89.

Aluminum alloys for aircraft. Rey nolds Metals Co. Bulletin Lf-436.

Platinum Metal Catalysts. Baker Co., Inc. Bulletin Af-337.

Die casting equipment. Leste Phoenix, Inc. Bulletin Kf-437.

Cerrosafe, a low temperature mel ing metal, used to accurately prod cast cavities. Cerro de Pasco Cop per Corp. Bulletin Kf-421.

Aluminum Castings. Nationa Bronze & Aluminum Foundry C Bulletin De-307.

Brass and bronze castings. Ham mond Brass Works. Bulletin Df-37

Reference on properties of lea St. Joseph Lead Co. Bulletin If-41

Catalog of brass, bronze and ir alloys. Cramp Brass and Iron Fou dries Div., Baldwin Locomotiv Works. Bulletin Gf-67.

Dowmetal data book. Dow Chem cal Co. Bulletin Ec-215.

80-page Duronze Manual, well in dexed for reference, presents da on high strength silicon bronze Bridgeport Brass Co. Bulletin N 163.

Forgeable tin-free bearing meta Mueller Brass Co. Bulletin Cg-481.

Surface protection for magnesium American Magnesium Corp. Bulleti Cg-482.

Rare metals, alloys and ores. Foo Mineral Co. Bulletin Cg-483.

Attractive booklet on Bunting ca bronze, sleeve type standardize bearings. Bunting Brass & Bron Co. Bulletin Cg-473.

New pamphlet covers standar specifications for all grades of alu minum alloys (casting grades only Federated Metals Div., America Smelting and Refining Co. Bulleti Cg-478.

New engineering data sheet No.1 announces extruded Ampco Met produced in new extrusion mi Ampco Metal, Inc. Bulletin Dg-17

Everyone joining nonferrous me als needs the new 12-page Westin house Brazing Booklet, cramme with timely ideas for saving ma hours and critical materials. Wes inghouse Elec. & Mfg. Co. Bulleti Dg-134.

WELDING

Welding Stainless. Page Steel Wire Div., American Chain & Cabl Co., Inc. Bulletin Ne-86.

Chart explains how to select prope flux for every welding, brazing an soldering job. Krembs & Co. Bu letin Ff-393.

Electrode quantity and weldin time graph. Arcos Corp. Bulleti Ld-191.

"Fight-waste" booklet. Air Reduc tion Sales Co. Bulletin If-69.

Oxy-acetylene welding and cutting Linde Air Products Co. Bulletin G 63.

Use Handy Coupon on Page 620 for Ordering Helpful Literature. Other Manufacturers' Literature Listed on Pages 620, 624, 626, 628, 63 632 and 634.

WHAT'S NEW

IN MANUFACTURERS' LITERATURE

Arc welding accessories available through General Electric Co. are illustrated in new Bulletin Lf-60.

Sciaky radial portable welder. Sciaky Brothers. Bulletin Kf-425.

Castolin Eutectic Alloys as a substitute for scarce bronze or brass welding rods. Eutectic Welding Alloys Co. Bulletin Lf-301.

Two-stage "Regolator" for producing a non-fluctuating welding flame. National Cylinder Gas Co. Bulletin Af-331.

Speed is increased 20 to 30% and power costs cut one-third with the Flexarc A-C welders described in new booklet by Westinghouse Electric & Mfg. Co. Bulletin Ag-134.

Shield Arc electrodes. McKay Co. Bulletin Gf-248.

Preheating, welding and normalizing by electrical reaction and induction is described in leaflet by Electric Arc, Inc. Bulletin Ag-468.

New precision welder with the streamlined arc is described in leaflet issued by Hercules Electric & Mfg. Co., Inc. Bulletin Nf-470.

"Sureweld" protected arc electrodes, in many types and sizes, described in illustrated literature. Hollup Corp., division of National Cylinder Gas Co. Bulletin Ag-331.

Data book facts on spot, seam and flash welding ferrous and non-ferrous metals and alloys. P. R. Mallory & Co., Inc. Bulletin Cg-220.

Welding and brazing of aluminum, a new data book issued by Aluminum Co. of America. Bulletin Cg-5

Silver Red electrodes for cutting tools and Silver Green electrodes for chisel steels are described in data sheets just added to the catalog of arc welding equipment issued by American Agile Corp. Bulletin Dg-485.

Savings in solder and other advantages of the new fusion process developed by Fusion Engineering described in new leaflet. Bulletin Dg-488.

Modern goal in equipment design and welding technique is outlined in bulletin "New Advances in Arc Welding Equipment Design" by Harnischfeger Corp. Bulletin Dg-171.

TESTING & CONTROL

X-ray crystal analysis apparatus is described and illustrated in new folder by Philips Metalix Corp. Bulletin Bg-471.

New 29-page catalog — Micromax Electric Control — has just been issued by Leeds & Northrup Co. Bulletin Bg-46.

Wheelco Instruments Co. has just issued five new bulletins describing its complete line of industrial indicating, recording and control thermometers. Bulletin Bg-110.

"Kodak Products for Industrial Radiography". Eastman Kodak Co. Bulletin Ff-395.

Bristol Co. has issued series of bulletins covering automatic control and recording instruments for industrial furnaces, dryers, kilns and ovens. Bulletin Bg-87.

Inspection of non-magnetic metals with the new Zyglo method. Magnaflux Corp. Bulletin If-401.

Industrial radiography with radium. Canadian Radium & Uranium Corp. Bulletin Ff-320.

X-Ray Diffraction Unit. General Electric X-ray Corp. Bulletin Hc-6

Use Handy Coupon on Page 620 for Ordering Helpful Literature. Other Manufacturers' Literature Listed on Pages 620, 622, 626, 628, 630, 632 and 634.

WHAT'S NEW

IN MANUFACTURERS' LITERATURE

Radium for industrial radiography. Radium Chemical Co., Inc. Bulletin Bf-345.

Film and plate processing equipment for spectro analysis. Harry W. Dietert Co. Bulletin Af-198.

Pyrometer Controller. Illinois Testing Laboratories, Inc. Bulletin Hb-180.

Optical Aids. Bausch & Lomb Optical Co. Bulletin Ce-35.

Universal testing machines and typical uses. Riehle Testing Machine Div., American Machine and Metals, Inc. Bulletin Cf-157.

Metallographic polishing powder. Conrad Wolff. Bulletin Cf-368.

Portable Brinell hardness tester and folding Brinell microscope. Andrew King. Bulletin Df-377.

8-page leaflet makes a detailed presentation of the Coleman universal spectrophotometer. Wilkens-Anderson Co. Bulletin Lf-7.

Laboratory and industrial electric furnaces manufactured by Cooley Electric Mfg. Corp. are described in new Bulletin Lf-462.

Automatic stress-strain recording. Baldwin-Southwark Div., Baldwin Locomotive Works. Bulletin Lf-67.

Metallurgical Equipment. Adolph I. Buehler. Bulletin Ke-135.

Hardness testing equipment. Wilson Mechanical Instrument Co., Inc. Bulletin Cf-22.

Modern Polishing. Tracy C. Jarrett. Bulletin De-303.

Potentiometer temperature indicators. Foxboro Co. Bulletin Ef-21.

Gage blocks, comparators, projectors. George Scherr Co. Bulletin Kf-206.

Slomin high speed electrolytic analyzers and other metallurgical laboratory equipment. E. H. Sargent & Co. Bulletin Kf-458.

Surface Analyzer. Brush Development Company. Bulletin Kd-288.

Polishing Machine. Cincinnati Electrical Tool Co. Bulletin Ox-97.

Micro-Optical Pyrometers. Pyrometer Instrument Co. Bulletin Kc-37.

X-Ray metallurgical laboratory service is described and illustrated in new file folder issued by Claud S. Gordon Co. Bulletin Nf-53.

64-page booklet on the precision control of industrial processes. Brown Instrument Co. Bulletin Nf-3.

Constant temperature dry-ice cabinet for temperatures from minus 90 deg. to 220 deg. F. is new laboratory instrument described in leaflet by American Instrument Co. Bulletin Ag-259.

Dillon tensile tester and the Dillon dynamometer are described and illustrated in new leaflet issued by W. C. Dillon & Co. Bulletin Ag-466.

An innovation in the manual methods of gas analysis known as Catalysis is described in leaflet by Burrell Technical Supply Co. Method is said to be faster, safer, more accurate. Bulletin Dg-213.

New catalog and engineering data book on new developments in industrial thermocouples. Arklay S. Richards Co. Bulletin Dg-330.

HEATING • HEAT TREATMENT

Tempering, annealing, stress-relieving. Leeds & Northrup Co. Bulletin Hf-46.

56-page vest pocket data book on heat treating practices and procedures. Chicago Flexible Shaft Co. Bulletin Hf-49.

24-page catalog describes gas, oil and electric Holden heat treating pot furnaces, and baths. A. F. Holden Co. Bulletin Lf-55.

Modern electric furnaces for heat treating are described by Harold E. Trent Co. in new Bulletin Lf-461.

New 8-page booklet describes and illustrates gas, oil and electric heat treating and carburizing furnaces of Holcroft & Co. Bulletin Lf-203.

Faster production with Tocco hardening, brazing, annealing and heating machines is set forth in new 16-page booklet by Ohio Crankshaft Co. Bulletin Lf-145.

Kleen-well oil strainers for quench oil cooling systems is described in leaflet by Bell & Gossett Co. Bulletin Lf-287.

Gas cracking unit for production of a protective atmosphere during heat treatment of alloy and high carbon tool steels is described by Hevi-Duty Electric Co. in new Bulletin Lf-44.

Unichrome alkaline copper processes for improvement of selective hardening and deep drawing of steel are described by United Chromium Inc., in new Bulletin Lf-463.

Handling cylinder anhydrous ammonia for metal treaters. Armour Ammonia Works, division of Armour and Co. Bulletin Lf-443.

"Pulverized Coal, the Victory Fuel". Amsler-Morton Co. Bulletin Ff-286.

Heat treating furnaces. Johnston Mfg. Co. Bulletin Ff-155.

Heat treating production. Lindberg Engineering Co. Bulletin Bf-66.

Rotary Hearth Furnaces. Lee Wilson Sales Corp. Bulletin Ce-302.

Industrial furnaces, equipment for bright annealing stainless steels and ammonia dissociation equipment. Drever Co. Bulletin Ff-321.

Industrial ovens, rod bakers, welding rod ovens, furnaces. Carl-Mayer Corp. Bulletin Bf-183.

Non-metallic Electric Heating Elements. Globar Div., Carborundum Co. Bulletin Lb-25.

Industrial Furnaces. W. S. Rockwell Co. Bulletin Kc-34.

Certain Curtain Furnaces. C. I. Hayes, Inc. Bulletin Nc-15.

Modern Shell Furnaces. Mahr Manufacturing Co. Bulletin Bf-5.

Use Handy Coupon on Page 620 for Ordering Helpful Literature. Other Manufacturers' Literature Listed on Pages 620, 622, 624, 628, 630, 632 and 634.

WHAT'S NEW

IN MANUFACTURERS' LITERATU

Heat treatment in electric salt ba furnaces. Ajax Electric Co., Inc. Bu letin If-43.

Molten Salt Baths. E. I. DuPo de Nemours & Co., Inc., Electrochem icals Department. Bulletin If-413.

Vertical Furnace. Sentry Co. Bu letin Ne-114.

Conveyor Furnaces. Electric Fu nace Co. Bulletin Be-30.

Industrial Carburetors. C. Kemp Mfg. Co. Bulletin Ce-219.

New Electric Furnace. America Electric Furnace Co. Bulletin G4

Furnace Experience. Flinn & Dre fein Co. Bulletin Bc-82.

Dehumidifier. Pittsburgh Lectr dryer Corp. Bulletin Bb-187.

Furnaces. Dempsey Industrial Fu nace Corp. Bulletin Ke-260.

High Temperature Fans. Michiga Products Corp. Bulletin Hb-81.

Turbo-compressors. Spencer Tu bine Co. Bulletin Cf-70.

Drycolene. General Electric Fu nace atmosphere. Bulletin Df-60.

Electric Furnaces for laborator and production heat treatment. Ho kins Mfg. Co. Bulletin Cf-24.

Control of temperatures of quench ing baths. Niagara Blower Co. Bu letin Cf-367.

Electric box type and muffle fu naces. H. O. Swoboda, Inc. Bulleti Ef-379.

Lithco, the chemically-neutral hea treating process, and Lithcarb, th process for fast, bright gas-carburi ing. Lithium Corp. Bulletin Ef-319.

Dual-Action quenching oil. Gu Oil Co. Bulletin Df-360.

Internally heated salt bath furnace and pots. Upton Electric Furna Div. Bulletin Ef-386.

Induction heating. Induction Hea ing Corp. Bulletin Ef-323.

Sub-zero equipment for aluminu storage, shrinking of metal part Kold-Hold Mfg. Co. Bulletin Kf-39

8-page pictorial bulletin describe the heat treating service of Conti nental Industrial Engineers, Inc. Bu letin Nf-154.

S.F.E. Standard Industrial furnac catalog. Standard Fuel Engineerin Co. Bulletin Kf-388.

New Heat Source, for Heat Treat ing, Brazing and Melting of ferrou and non-ferrous metals. Lepel Hig Frequency Laboratories, Inc. Bulle tin Kc-211.

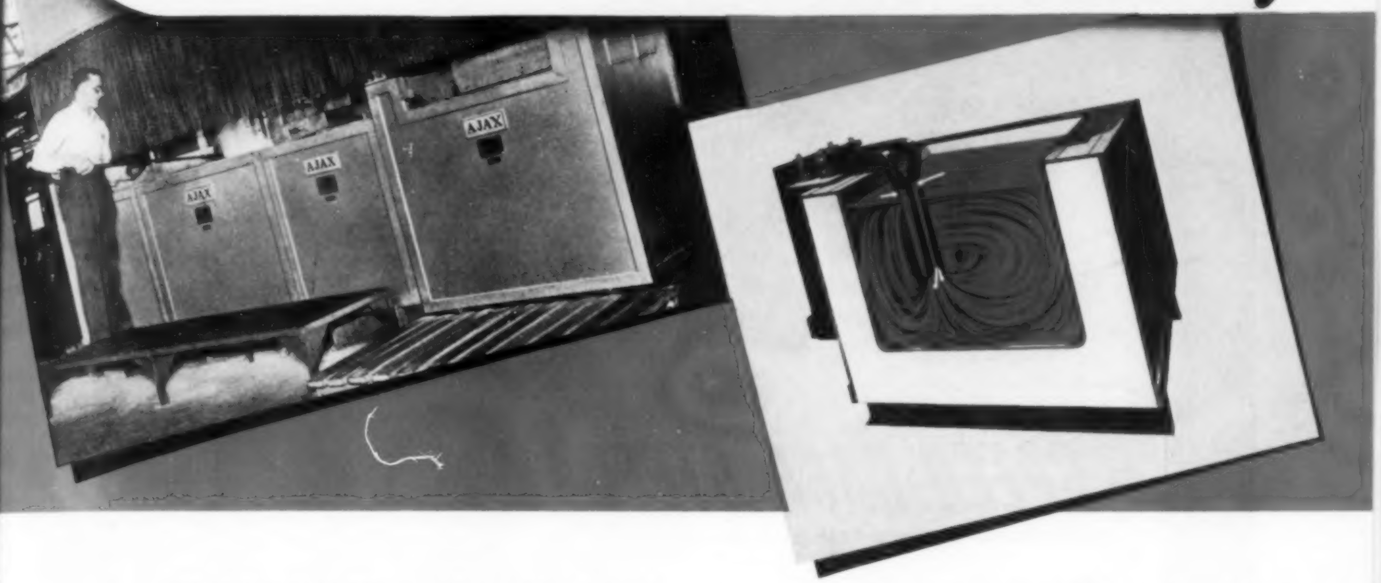
New manual shows many ne technical advances — features exclu sive, easy-selection charts on ga burning equipment. National Ma chine Works. Bulletin Ag-310.

Flame-type mouth and taper an nealing machine for steel cartridg cases is described in new leaflet by Morrison Engineering Corp. Bulletin Nf-305.

Electric Furnaces. Ajax Electro thermic Corp. Bulletin He-41.

Use Handy Coupon on Page 620 for Ordering Helpful Literature. Other Manufacturers' Literature Listed on Pages 620, 622, 624, 626, 630, 632 and 634.

Certain things come FIRST
. . . in Heat Treating!



. . . A RECORD WITHOUT PARALLEL IN THE HEAT TREATING FIELD!

American industry has invested millions of dollars in Ajax-Hultgren electric salt bath furnaces. And based upon the unique Ajax electrode heating-and-circulating principle, the following facts bear relation to your present and future requirements:

Ajax was first to *mechanize* salt baths . . . First to use *ceramic pots* for neutral hardening . . . First to use welded boiler plate furnace pots for *carburizing* . . . First to develop salt bath furnaces for *deep-case carburizing* (up to .125") . . . First to harden *high speed steel tools* successfully . . . First to discover and apply salt baths for *brazing* and for *simultaneous brazing* and *carburizing* . . .

All heat is generated within the bath, using the liquid salt itself as a resistor between the closely-spaced electrodes. Electromotive forces at the electrodes produce a vigorous circulation throughout the bath, as indicated by the arrows. Only the Ajax furnace possesses this electromotive circulation—the flow that inhibits temperature differences anywhere in the bath.

The largest salt baths for heat treating aluminum alloys were installed by Ajax . . . Ajax was first to develop salt bath *heating for forging*—and likewise first to develop the only salt baths used for hardening *armor-piercing shot* and a host of armament applications still on the list of wartime secrets.

Certain things come first in heat treating: Low cost, overall efficiency, maximum output—highest quality of end product with the simplest means. Perhaps that is why the connected load of over a thousand Ajax furnaces since 1936 totals more than 100,000 KW today.* Write for Bulletin 107-A.

AJAX ELECTRIC COMPANY, Inc., Frankford Ave. at Delaware Ave., Philadelphia, Pa.

*THERE'S AN AJAX INSTALLATION NEAR YOU!

THE AJAX HULTGREN ELECTRIC SALT BATH FURNACE

SELF-HEATING • SELF-CIRCULATING

ASSOCIATE COMPANIES:
AJAX METAL COMPANY, *Non-Ferrous Ingot Metals and Alloys for Foundry Use*
AJAX ELECTROTHERMIC CORPORATION, *Ajax-Northrup High Frequency Induction Furnaces*
AJAX ELECTRIC FURNACE CORPORATION, *Ajax-Wyatt Induction Furnaces for Melting*
AJAX ENGINEERING CORPORATION, *Ajax-Tama-Wyatt Aluminum Melting Induction Furnaces*

WHAT'S NEW

IN MANUFACTURERS' LITERATURE

No-Carb, a liquid paint for prevention of carburization or decarburization. Park Chemical Co. Bulletin Nf-141.

16-page engineering and data booklet on proportioning oil burners. Hauck Mfg. Co. Bulletin Nf-181.

Pictorial bulletin describes furnaces for heat treating, normalizing, annealing, forging. Vulcan Corp. Bulletin Ag-448.

Attractive 16-page illustrated catalog describes furnaces for heat treating ferrous and non-ferrous metals. Despatch Oven Co. Bulletin Ag-12

War production with standard-rated heat treating furnaces is pictured in new bulletin by Surface Combustion. Bulletin Ag-51.

Gas-burning equipment. National Machine Works. Bulletin Fe-310.

Interesting and helpful information available on the use of alloy pots for heating operation by the Swedish Crucible Steel Co. Bulletin Cg-484.

Gas-air premix machine is described and illustrated in new bulletin by Eclipse Fuel Engineering Co. Bulletin Cg-226.

Two new bulletins on vertical carburizers and on carbonia finish issued by American Gas Furnace Co. Bulletin Cg-11.

Hagan rotary forging furnaces are described and illustrated in a new bulletin just issued by George J. Hagan Co. Bulletin Cg-476.

Low temperature equipment for aging, shrinking, etc. Deepfreeze Div., Motor Products Corp. Bulletin Kf-444.

Heat treating furnaces. McCann Furnace Co. Bulletin Kf-446.

Controlled atmosphere furnace for heat treatment of tool and alloy steels. Delaware Tool Steel Corp. Bulletin Kf-439.

Furnaces. Tate-Jones Co. Bulletin Kf-447.

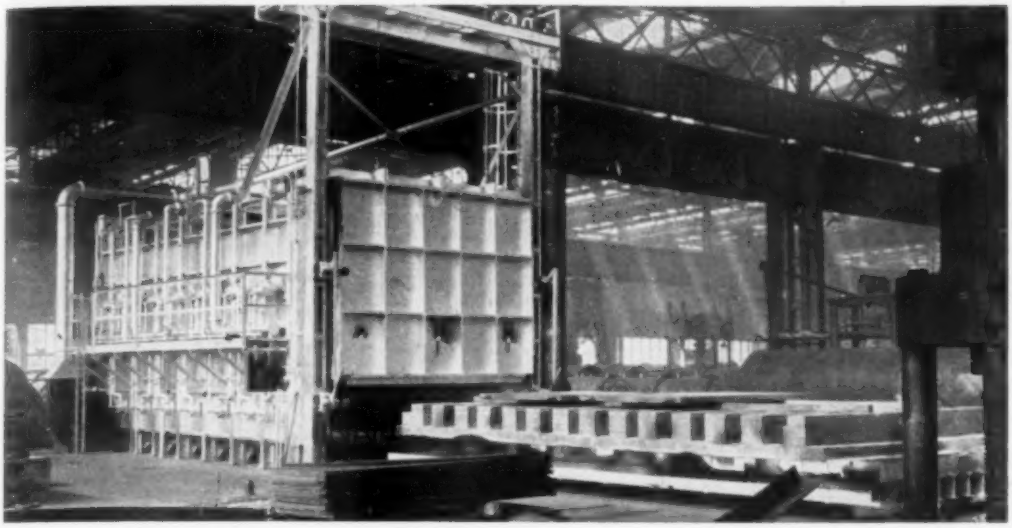
Newly developed salt bath material for use in Martempering process is described in 8-page folder by E. F. Houghton & Co. Bulletin Dg-38

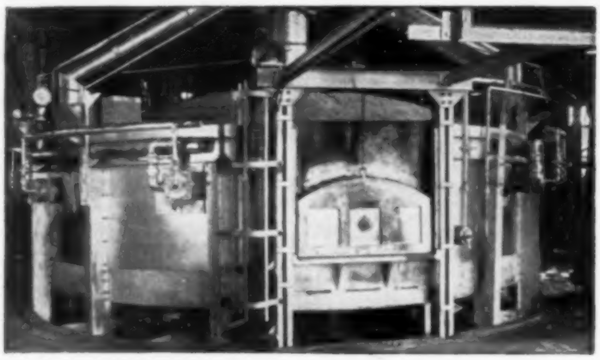
Hy-Speed Case for increasing the life of high speed tools is described in 4-page leaflet by A. F. Holden Co. Bulletin Dg-55.

New Van Norman induction heating units are comprehensively described and typical operations pictured in attractive 8-page folder by Van Norman Machine Tool Co. Bulletin Dg-487.

New 8-page, well-illustrated catalog describes equipment for flame-hardening, flame-annealing, mechanized-brazing, preheating and other localized open heat treatments by the Selas Co. Bulletin Dg-214.

Use Handy Coupon on Page 620 for Ordering Helpful Literature. Other Manufacturers' Literature Listed on Pages 620, 622, 624, 626, 628, 632 and 634.





WHAT'S NEW

IN MANUFACTURERS' LITERATURE

High and low temperature direct fired furnaces as well as convection types for stress relieving and drawing are described in new 8-page leaflet by R-S Products Corp. Bulletin Dg-234.

Air-Oil Ratiotrol for proportioning flow of fuel oil and air to oil burners is described in new bulletin by the North American Mfg. Co. Bulletin Dg-138.

Blue Print for Industry is title of new data book presenting oven engineering information on 28 installations with description of design and process. Industrial Oven Engineering Co. Bulletin Dg-494.

REFRACTORIES & INSULATION

Insulating firebrick. Babcock & Wilcox Co. Bulletin Ce-75.

Heavy Duty Refractories. Norton Co. Bulletin Ie-88.

Super Refractories catalog. Carborundum Co. Bulletin Ld-57.

P. B. Sillimanite refractories. Chas. Taylor Sons Co. Bulletin Ef-218.

Conductivity and heat transfer charts. Johns-Manville. Bulletin Df-100.

Savings in construction time, labor and money with use of the all Ramix bottom for basic open hearth furnaces are shown in new leaflet by Basic Refractories, Inc. Bulletin Nf-192.

Brickseal refractory coating and discussion of why furnace walls break down are presented by Brickseal Refractory Co. Bulletin Ag-469.

Corhart Electrocast Refractories for the melting and refining of metals are described by Corhart Refractories Co. Bulletin Dg-493.

FINISHING, PLATING, CLEANING

Nielco Laboratories offers technical data sheet on brass and copper alkali cleaner. Bulletin Bg-472.

Technical and engineering data on Tygon and typical uses, such as tank linings, are presented by United States Stoneware Co. in new Bulletin Lf-356.

Detrex metal cleaning machines, metal cleaning chemicals and processing equipment are attractively described in new 24-page catalog by Detroit Rex Products Co. Bulletin Lf-111.

Airless Rotoblast. Pangborn Corp. Bulletin Hf-68.

A protective, deep black finish for steel. Heatbath Corp. Bulletin Hf-189.

Alvey Ferguson Co. shows how various product washing problems were solved. Bulletin Ne-329.

Pickling. Wm. M. Parkin Co. Bulletin Ff-193.

Modern Pickling. The Enthone Co. Bulletin Ff-240.

Cadmium Plating. E. I. duPont deNemours & Co., Inc. Bulletin Hd-29.

Anodizing and plating equipment. Lasalco, Inc. Bulletin Kf-457.

"Indium and Indium Plating". Indium Corp. of America. Bulletin Df-376.

Degreasers. Phillips Manufacturing Co. Bulletin Nc-254.

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Standard and special shapes o seamless steel tubing are describe and pictured in new leaflet by Sum merill Tubing Co. Bulletin Lf-108.

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New 48-page catalog describe place of manganese steel, an answers many questions. America Manganese Steel Div., America Brake Shoe & Foundry Co. Bulleti Cg-9.

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Alloy Castings. Ohio Steel Foundr Co. Bulletin Dg-40.

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